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Mechanical manipulation of the three position semaphore arms on the Belgian State Railways,

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Figs. 1 to 83, pp. 620 to 694.

Putting the principles of the new method of signalling into operation which were adopted in 1919 by the Administration of the Belgian State Railways (1) necessitated the provision of new apparatus and arrangements. The difficulty in the problem consisted principally in accurately bringing the semaphore arm, that is worked at a distance, and by mechanical means, into one of the three positions, horizontal, inclined at 45°, or vertical, in spite of the changes which take place in any transmission of power by wires, owing to stretching and change of temperature.

As the subject of the apparatus in the new method of signalling is intimately connected with that of the transmission of power for working it, it is necessary that, first of all, the system of working by double wire as used on the Belgian State Railways should be described.

CHAPTER I.

Transmission of power by double wire for working the signals on the Belgian State Railways.

The Administration of the Belgian State Railways adopted the double wire in place of the single wire system for working signals in 1904.

(1) See article on the « New system of signalling on the Belgian State Railways » by Mr. J. Verdeyen, chief engineer and inspector of operation on the Belgian State Railways (*Bulletin* for May 1923).

The advantage of double over single wire transmission is chiefly due to the fact that it ensures with greater certainty absolute agreement between the position of the signal and that of the lever working it, in fact, thanks to the return wire, this lever ensures the placing of the arm at danger, as it brings about its line clear position, by means of the wire in tension.

Fig. 1. — Disc distant signal worked with single wire.

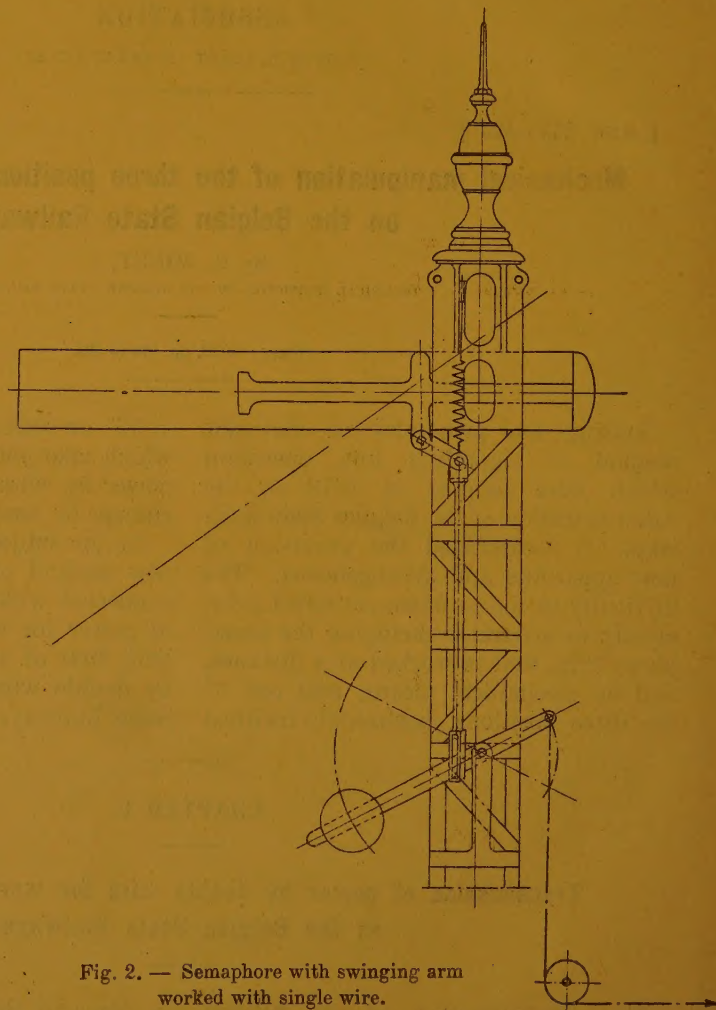

Fig. 2. — Semaphore with swinging arm worked with single wire.

Inconveniences of transmission of power by single wire. — With single wire working, the hand lever has only direct control for the line clear position of the arm. In order to be placed at danger, the latter is either subjected to

the action of a balanceweight, as in the case of the stop discs of distant signals (fig. 1) and with the ordinary semaphores with arms that make an angle of 45° in a downward direction to show line clear (fig. 2), or else under the action of the weight of the arm itself in the case of semaphores with rising arms (fig. 3).

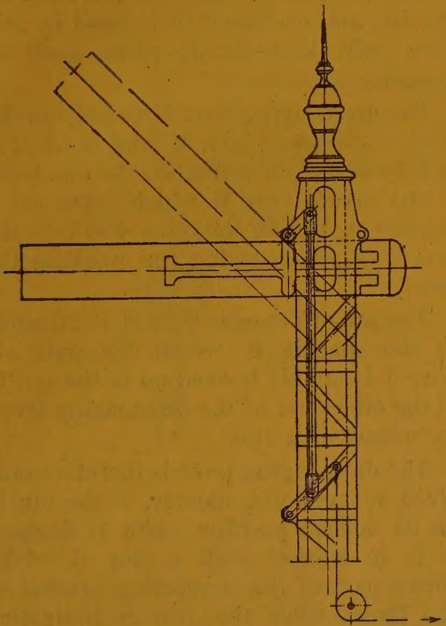

Fig. 3. — Semaphore with a rising arm worked with single wire.

This action, due to the balanceweight or to the arm itself, is expected to overcome frictional resistances of the transmission wire on bringing this back to its original position when the lever is placed in its normal position. These resistances are, however, considerably increased on account of atmospheric conditions such as, a strong wind, falls of snow, or by frost, and it has often been observed that signals worked in this way and showing line clear for some length of time did not return to the danger position after placing the lever to show this position; this was simply due to the action of the balanceweight or signal arm not being able to overcome the frictional resistances of the transmission wire.

A signal worked with a single wire may also accidentally remain at the line clear position on account of the wire being caught by some obstacle (such as, rail or pieces of wood, etc., thrown unintentionally on to it), or else after the signal has been pulled off for some time, by the freezing of the grease mixed with water or snow in the joints of the signal itself.

Finally, it is possible to lower the signal, unknown to the signalman, by pulling the wire at any point in its length, though the lever itself is standing in the danger position.

Working with double wire. — The double wire arrangement offers a solution for these inconveniences by making use of, either a pulley (for instance the pulley of the German semaphores and commonly called « snail ») or else a balance lever on the signal itself.

Ordinary balance lever. — It should be pointed out that if only a simple balance lever is used as shown in the diagram, figure 4, the inconvenience of the single wire working may be reproduced in case the pull to danger wire should break.

Breaking the pull off wire would not be dangerous, for supposing it happened when the arm was standing at danger, it would be materially impossible to take the signal off by means of the hand lever. If on the contrary the wire broke when the arm was giving line clear, the pull to danger wire would bring it to

danger at the instant the hand lever was replaced in its normal position.

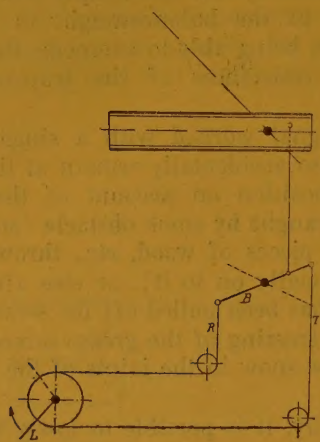

Fig. 4.

The consequences resulting from the breaking of the pull to danger wire are otherwise serious, and are in fact the only ones that need be considered, for if this wire broke when the arm was at danger, it would always be possible to put the signal to line clear, because the pull off wire is still intact. At the moment, however, when the hand lever is placed in its normal position, as the pull to danger wire can no longer act, the return of the arm to the danger position depends on the action of its own weight, and in most cases this is insufficient to overcome the passive resistances in the pull off wire.

It was therefore necessary to design a special arrangement to overcome the trouble that might arise if the pull to danger wire should happen to break.

The contrivance used on the Belgian State Railways for this purpose is the disengaging lever.

Disengaging lever (fig. 5). — This device is constructed in such a way that in case the pull to danger wire breaks, the pull off wire unhooks itself automatically, either at the exact instant when rupture occurs, the arm at the time showing line clear, or else at the first application of the hand lever, when the arm is at danger. The pull off wire, unhooking itself at the time the arm is raised, the latter, under the influence of gravity, and no longer influenced by this wire, will immediately place itself at danger.

The disengaging lever D swivels on the boss of the crank arm M, and is coupled at F by means of a pin, on the one hand to the crank arm M which turns on a spindle O, and on the other hand, to the jaw E of the coupling rod working the arm.

The pull to danger wire R is attached to the shackle B, whilst the pull off wire T is simply hooked on to the tail C, at the other end of the disengaging lever, by means of a link.

The disengaging lever is therefore only fixed at one point, namely, at the pin F. In its normal position (arm at danger) it is in contact with a stop G which forms part of the supporting bracket of the lever; when the arm is indicating line clear and the position of the lever is reversed, it comes into contact with a second stop G′ on the same support. The two stops G and G′ serve therefore to regulate the travel of the lever.

The disengaging lever should not rise from its seating while it is working, and in order to obtain this result when adjusting the wires, a somewhat higher tension is generally given to the pull to danger wire than to the pull off wire.

This slight extra tension has also the effect of preventing irregular unhooking of the pull off wire when this is being

worked. As we shall see further on, these unhookings are always the result of defective adjustment of the transmission arrangement.

Action of the disengaging lever in case the pull to danger wire breaks. — If the pull to danger wire breaks at the time the arm is placed at line clear, the tension in this wire being theoretically zero, and the pull off wire being at this moment under full working tension, the disengaging lever under the influence of this wire turns round the spindle F and takes the position indicated by the dotted lines in figure 5. In this position the

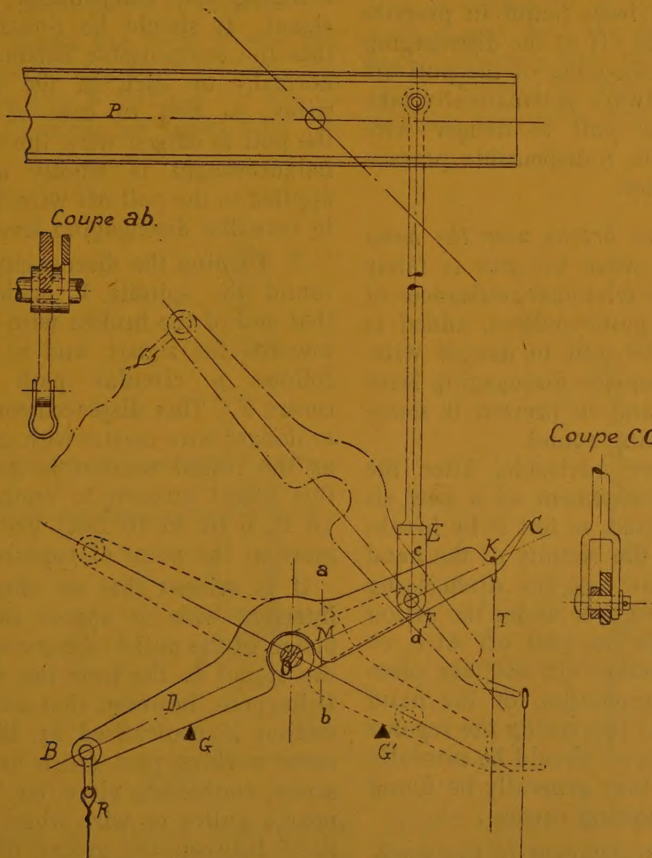

Fig. 5. — Disengaging lever.

tail C being inclined below the horizontal level, the link hung on to the tail slips off, carrying with it the pull off wire and so causing the arm to fall automatically into the danger position.

If the breaking of the pull to danger wire R takes place when the arm is at danger, it may happen that the pull off

wire T does not unhook itself instantaneously, this however is of no importance, because this wire will be obliged to fall at the first manipulation of the hand lever, so that the arm could not possibly place itself at line clear.

Precautions to be taken in order to ensure proper working of the disengaging lever. — It has been found in practice that the throwing off of the disengaging lever and the unhooking of the pull off wire does not always automatically take place, when the pull to danger wire breaks, if certain indispensible precautions are neglected.

When the wire breaks near the hand lever, especially when the run is fairly long, and all the frictional resistances of the return and guide pulleys, added to the weight of the pull to danger wire, contribute to keep the disengaging lever on its support and so prevent it sometimes from turning round.

It is therefore advisable, after the transmission arrangement of a new signal has been fixed, to test it by breaking the wire in the vicinity of the hand lever. If in this case the disengaging lever did not turn over under the action of the tension in the pull off wire, or at least if this action did not take place at the first manipulation of the hand lever, the reasons preventing the regular working of this lever should be carefully looked for, and may generally be found amongst the following causes :

1° Abnormal resistances to the working of the pull to danger wire, due : *a*) to the presence of a too large number of pulleys; *b*) to excessive friction due to defective fixing up and chiefly to the run of the wire not coinciding exactly with the centre of the grooves of the pulleys and guide wheels; *c*) to the want of lubrication of the pulleys and the chains themselves;

2° Insufficient initial tension in the two lines of wire; it is obviously necessary that in case the pull to danger wire breaks, the tension in the pull off wire may act strongly on the disengaging device, and this action may be assisted by bringing the compensator nearer the signal. It should be remarked in fact that the compensator balanceweight acts normally on each of the transmission wires, so that in case of rupture of the pull to danger wire, the action of the balanceweight is wholly and sharply applied to the pull off wire, thus tending to turn the disengaging lever;

3° Turning the disengaging lever over round the spindle F evidently causes that end of the broken wire to be pulled towards the signal, and in doing so it follows a circular path round the centre F. This displacement of the pull to danger wire occurs with greater force, as the initial tension is itself greater; this might amount to from 2 to 3 m. (6 ft. 6 in. to 10 feet) per second and more at the point of rupture.

It is evident that no obstacle should interfere with or oppose this recoiling action of the pull to danger wire towards the signal at the time the wire breaks. It happens, however, that sometimes this motion is neutralised by the fact that some working part (such as a coupling screw, connecting piece, etc.) placed too near a pulley or wire wheel may wedge itself between the groove of the pulley and its carrier and thus prevent the displacement of the disengaging lever;

4° Care should be taken that there is no obstacle which might prevent this lever rotating. The angle of the slope of the tail, which is determined when constructed by means of a gauge, must

not be altered under any pretext whatever. The solid link forming the end of the pull off wire and hung on to the tail should be, like the latter, perfectly smooth and of sufficient width, and at the inspections of the semaphore it should be seen that no hollow has been formed in this tail which might prevent the link from slipping off, even when the lever has been properly displaced.

Figure 5 shows the lever D and the crank M placed together between the cheeks of the jaw F forming the end of the rod which works the signal arm. In this case the amount the lever can turn round is limited by the bottom of the jaw. It is necessary therefore that the jaw should be sufficiently deep so that the angle of the displaced lever should be sufficient to allow the link, hooked on to the tail, to slip off.

The coupling rod working the semaphore arms in the new system of signalling is joined to the crank M only in such a way that the disengaging lever may completely turn to the proper position. Figures 6 and 7 show respectively a semaphore arm of the old kind

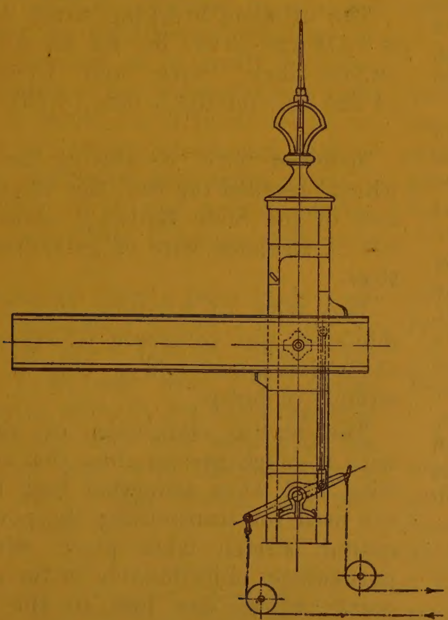

Fig. 6.

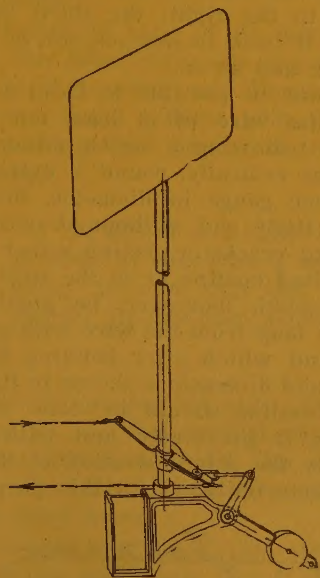

Fig. 7.

and a distant disc signal, both worked with the double wire through the medium of a disengaging lever.

Steel wires. — The Administration of the Belgian State Railways makes use of cast steel wire 4.19 mm. (0.165 inch) diameter for signal working, and 5 mm. (0.197 inch) diameter for working points and the bolts of these points.

According to the specifications in present use, these steel wires should satisfy the following conditions :

A. — The steel should be capable of being properly tempered after being heated to cherry red.

B. — The resistance to fracture per square millimetre of sectional area should be at least 100 kgr. (142 230 lb per square inch) with a maximum elongation of 5 % measured over 200 mm. (8 inches) between gauged points.

C. — The number of successive bendings from right to left the steel wires must undergo without fracture in a vice, whose edges are rounded to a radius of 10 mm. (3/8 inch), must be at least ten for 4.19 mm. (0.165 inch) wires, and at least 8 for 5 mm. (0.197 inch) wires. The wire is fixed vertically in the vice and is first bent 90° to the left, and then through an angle of 180° so as to bring it 90° to the right; the third bending brings it back to the position of 90° to the left, and so on.

It must be possible to form a spiral with the wire of at least ten turns, without showing a crack either sideways or centrally, round a cylinder of the same gauge in diameter, therefore round itself and without showing any splitting, cracks or peeling, either in the galvanised coating or in the steel itself.

It should, moreover, be possible to form a loop from the wire with parallel legs, and which after bending has the shape and dimensions shown in figure 8. This bending should be done without heating it previously and with pliers used by the Administration of the Belgian State Railways for this purpose.

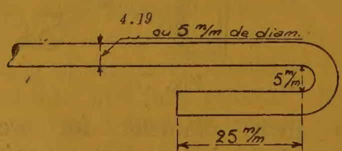

Fig. 8.

No splitting or cracking must result from this bending either in the galvanised coating or in the steel itself.

D. — The galvanised surface of pure zinc should show neither splits, cracks nor drops of metal, and the wire should be able to support, without becoming bare or red, even partially, four dippings of a minute each in a solution made up of one part sulphate of copper and five parts water.

Before dipping, the wire is rolled round a cylinder 4 cm. (1 9/16 inches) in diameter, and the coating of zinc must not split or peel away in any part during the tests as described above.

E. — The steel wire must be delivered in coils weighing from 40 to 50 kgr. (88 to 110 lb.) and the lengths of the wire in each coil should be as long as possible.

The ultimate breaking strain allowed is 1 378 kgr. (3 037 lb.) for the 4.19 mm. (0.165 inch) wire, and 1 962 kgr. (4 325 lb.) for the 5 mm. (0.197 inch).

Stranded wire. — During the years which preceded the war, the Administration of the State Railways made large use of stranded wire of galvanised cast steel.

This wire, of 6.9 mm. (0.272 inch) diameter, was composed of six strands of twelve wires and a core of seven strands of hemp.

The elastic elongation of stranded wire is much greater than that of steel wire, and when somewhat long lengths are used for transmitting the power required, stretch takes place, which is particularly objectionable in the case of points where any loss in the stroke causes a proportional effect on the unbolting of the point when closed, and a displacement out of its proper position when open.

This elongation, however, is not the only inconvenience caused by stranded wire, for experience has proved that after a few years use it has deteriorated to such an extent that it ends by breaking, for it is in fact only necessary for one

of the strands of which it is made to break to seriously affect its powers of resistance. The life of stranded wire might be greatly lengthened if it were regularly greased by men charged to maintain it in good order, but in practice it would be difficult to properly look after installations that are fixed all over the line with any degree of care and regularity, and it has been proved that where these wires are in constant work it is necessary to renew them after about three years.

It will be seen therefore that in spite of the advantages possessed by stranded wire, such as lightness, flexibility, faculty, on account of its small diameter, of being able to use comparatively light pulleys, it would be difficult — on account of its serious drawbacks, such as excessive elongation and rapid wear — to make use of it, and several foreign railways who tried it temporarily gave it up.

It was found, chiefly from trials made on the Saxony State Railways during the period from the 1 January 1908 to the 1 April 1909, that with 2 875 points worked with wire, 64 fractures occurred with stranded wire and none with the plain wire, and with 3 688 signals, 3 wires were found broken and 103 stranded wires.

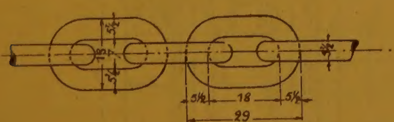

Fig. 9.

According to our information, no similar statistics have been got out on the Belgian State Railways, but the trials made with stranded wire showed that it constituted a weak point in the transmission of power, so it was decided to use instead light chains with small links (see fig. 9).

Light chains. — These are made of iron, hand welded, or else of steel electrically welded, the breaking strain of which must not be below 1 200 kgr. (2 640 lb.).

Stranded wire was never exclusively used on the Belgian State Railways, but instead, to a certain extent, either the light chain or else a stronger chain, the breaking strain of which amounted to 1 800 kgr. (3 960 lb.), with outside dimensions 36 mm. × 23 mm. (1 1/4 × 7/8 inches).

Nevertheless, in spite of its increased strength, this latter chain was abandoned on account of its weight and dimensions, which necessitated pulleys with larger grooves, making them heavier and more cumbersome.

Pulleys. — The adoption of light chains made it possible to construct a special type of pulley in cast iron 300 mm. (11 7/8 inches) in diameter shown in figure 10.

Vertical carriers for 300 mm. (11 7/8 inch) pulleys. — The vertical carriers for pulleys are fixed under the signal boxes for the outlet of the wires joined up to the hand levers.

These are of two kinds : the vertical carrier for one pulley only (fig. 11) used in those installations worked by means of rods, and vertical carriers for four pulleys (fig. 12) used in installations where points and signals are worked with the double wire arrangement.

The first kind of carrier is fitted with two holes which allows the pulley to be fixed by means of a pin at two different levels, for reasons which an examination of figure 13 will make clear.

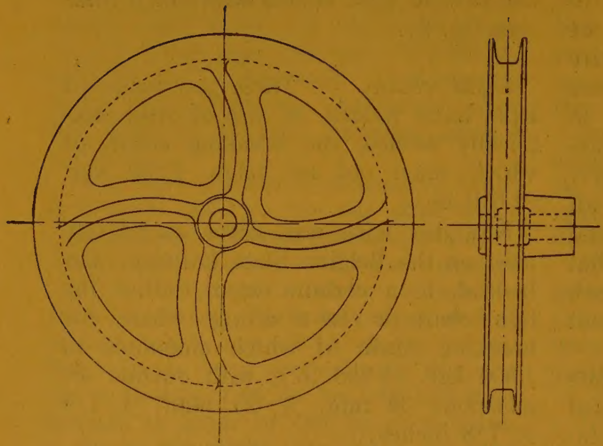

Fig. 10. — Pulley 300 mm. (11 7/8 inches) in diameter for light chains.

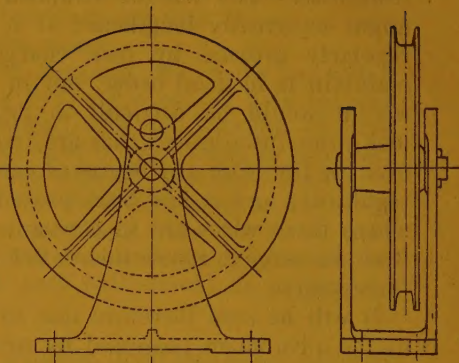

Fig. 11. — Vertical carrier for 300 mm. (11 7/8 inch) pulley.

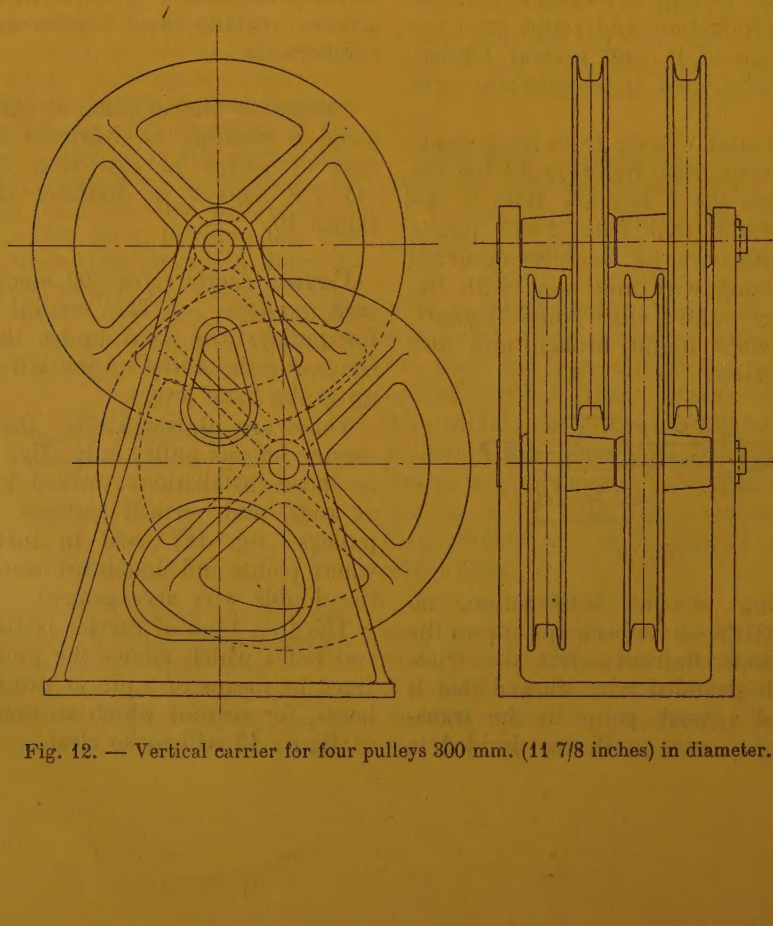

Fig. 12. — Vertical carrier for four pulleys 300 mm. (11 7/8 inches) in diameter.

Vertical carriers fitted with four pulleys are used for sending along double transmissions descending from two adjoining levers (fig. 14).

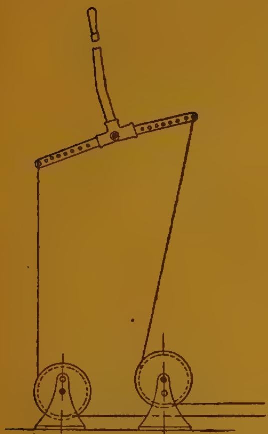

Fig. 13.

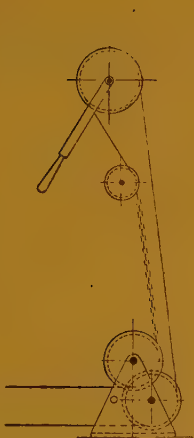

Fig. 14.

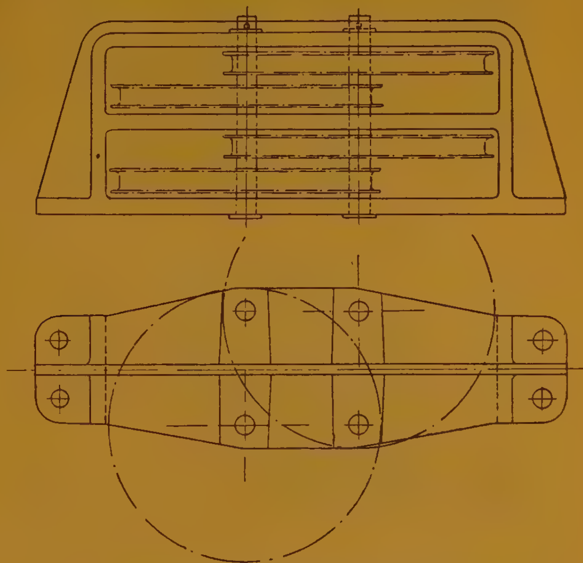

Fig. 15. — Horizontal frame with two stages and four pulleys 300 mm. (11 7/8 inches) in diameter.

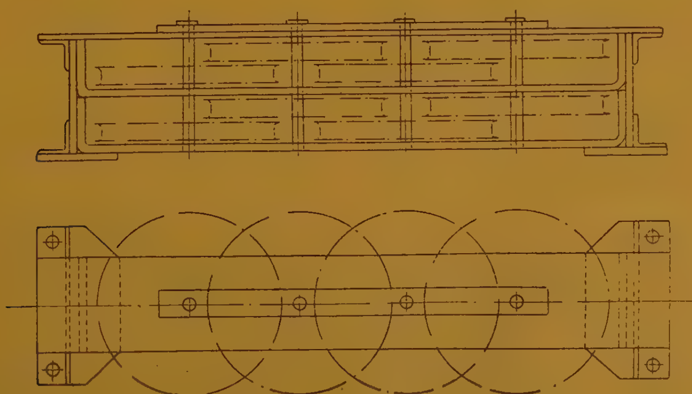

Fig. 16. — Horizontal frame with two stages and eight pulleys 300 mm. (11 7/8 inches) in diameter.

These contain three holes, one of which is at the top and in the vertical centre line of the carrier, thus allowing the pulley and its transmission wire to be at a higher level than the second pulley and its corresponding second wire, in order to avoid any friction from the wires rubbing together. The two lower holes

drilled on the same level allow the horizontal working of the wires to be effected either backwards or forwards.

Horizontal frames for pulleys. — For purposes of simplification, no frames for two pulleys only have been constructed. Frames made for four pulleys (fig. 15) are used for working four or two wires. In the latter case it is evident that only two pulleys are placed in the frame. Frames containing eight pulleys fixed in two stages (fig. 16) and even as many as twelve pulleys, also in two stages are used on account of the small vertical space they require when having to transmit their power underneath the lines, whilst frames containing eight pulleys fixed in four stages (fig. 17) as well as those with twelve pulleys, are placed just

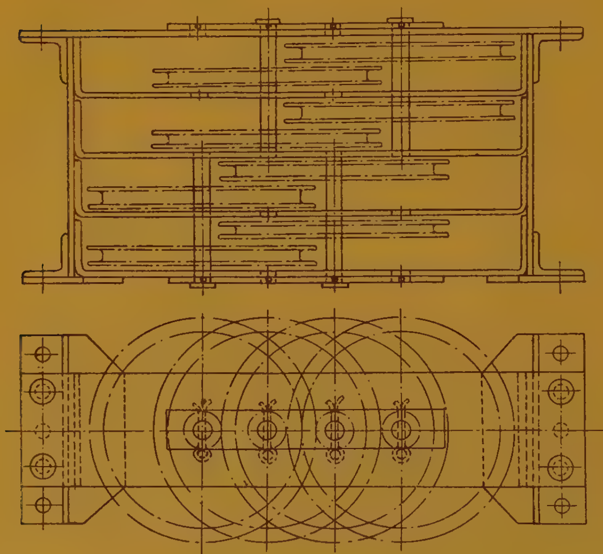

Fig. 17. — Horizontal frame with four stages and eight pulleys 300 mm. (11 7/8 inches) in diameter.

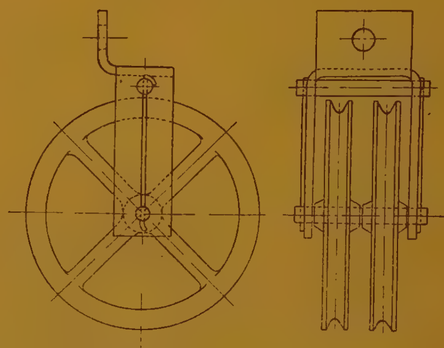

Fig. 18. — Guide pulley for wires.

outside the signal boxes, where the numerous wires being particularly close together, may be arranged in stages without inconvenience.

Horizontal frames are fixed by means of bolts to wooden tressels for a foundation. These tressels are made from rectangular pieces of wood 0.30 × 0.15 m. (11 7/8 × 5 7/8 inches) cut from material that had been in use and put out of service. These pieces of wood are assembled together so as to form a rather large base (about one square metre [10.76 square feet] for the simplest frames). The tressel thus formed is placed in the ground and rammed round with a mixture of soil and old ballast so that the frame keeps perfectly stable, even under the greatest strains that may be applied to it.

Guide pulley for wires (fig. 18). — The Administration of the Belgian State Railways uses guide pulleys for wires

made of malleable cast iron and 127 mm. (5 inches) in diameter. These pulleys are mounted in couples on a pin fixed in a carrier made from a stamping of mild steel. A second pin passing through the top part of the carrier prevents the wire from slipping out of the pulley groove.

On account of their lightness (they weigh 330 gr. [11 1/2 ozs] and their large diameter, the frictional resistance due to these pulleys is relatively small.

The pulley frame is fixed to the carrying post bracket by means of a bolt and can be placed at an angle when necessary, in cases where the wire has to pass round a curve, etc.

When this happens, a bracket should be fixed in such a way that the angle at which the frame is inclined keeps the lower part of the pulley away from the short post to which it is attached, otherwise the framing might cause the pulley to come into contact with the post and so cause unnecessary friction. When transmitting power round curves, the tension of the wires is adjusted before screwing up the nut of the suspension bolt. These pulleys find their correct position for themselves under the action of the tension in the transmitting wire.

Guide pulley carrying posts. — Before the war, either oak posts 0.12 × 0.12 m. (4 3/4 inches square), or else entirely metallic ones, described in the *Bulletin of the Railway Congress* for October 1907, were used.

Since the war, the high price of oak, as well as metallic posts, led us to suggest the adoption of a simple and cheaper kind.

As shown in figure 19, this post is formed from a « T » iron, the foot of which is coated with a mass of concrete of square section. This coating of concrete, while thoroughly protecting the metal, also presents a surface large enough to give to the post the requisite stability. The faces of the « T » iron are slightly jagged in order to give the concrete a better grip of the metal.

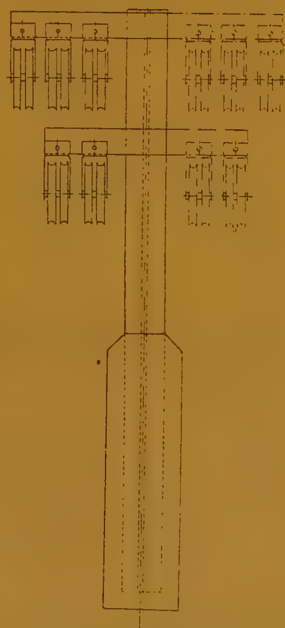

Fig. 19 — Metallic post
coated with a mass of concrete at its lower part.

Brackets. — The posts have been designed for carrying two kinds of brackets, those drilled with three holes and those with two (fig. 19). For purposes of standardisation, these brackets can be fastened to the post with the same size bolt as that used for attaching the wire guide pulleys, and can be fixed one above the other on the post and carry pulleys on each side of it. One post fitted with four three holed brackets can therefore carry a maximum of twenty-four guide pulleys for wires.

Coupling pieces. — The form of joints for coupling wires either together or to a chain has always been a subject of interest to railway companies. The danger of a broken wire is always kept in view, as it is well known that in case of this happening a signal might remain at its line clear position or cause a set of points to be out of pitch with its hand lever.

Soldered joints. — The Germans, during their occupation of our country, introduced on our railway system the soldered joint, which is in general use on German and Dutch railways.

This consists, as we know, of laying the two ends of the wires side by side for a distance of 100 to 120 mm. (4 to 4 3/4 inches) and soldering them together, this is then bound with thin steel wire and afterwards the whole joint thus made is varnished.

These joints are very strong when made with care, and their resistance to rupture is not less than the wire itself; they have, however, the objection of being costly, they take a long time to make and it is necessary to use a special solder.

Vincent coupling. — Until lately the Administration of the Belgian State Railways have made use of the Vincent coupling with split link in order to couple up either two wires or else a wire and light chain (fig. 20).

The Vincent coupling joint (fig. 21) is made of malleable cast iron, and the wire, after being threaded into it, is bent by means of a special tool into a hollow formed in its interior. The latter is provided with an eyelet through which either a split link or hook (fig. 22) is passed in case the wire is connected to stranded wire.

It is therefore necessary when joining two wires together to have two coupling pieces which are joined together by means of a split link, and when it concerns connecting a wire to a stranded wire, one coupling and a hook are necessary.

The breaking strain of the round split link does not exceed 600 kgr. (1 320 lb.) and consequently formed a weak point in the transmission arrangement, for the minimum resistance to fracture of a chain is 1 200 kgr. (2 640 lb.) and that of a 4.19 mm. (0.165 inch) wire of 1 378 kgr. (3 037 lb.).

Breakages of the transmission arrangement have been noticed fairly frequently in practice due to the opening of these split links, and also, but more rarely, the breaking of the coupling itself which happens to the outside portion of one of the two cheeks in which the eye-hole is made.

The problem therefore was to design a stronger coupling, the breaking strain of which approximated as nearly as possible to that of the chain and steel wire.

With this object in view, the Administration in 1922 had the round sectioned split link changed for one of rectangular section, the minimum breaking resistance of which was 1 000 kgr. (2 200 lb.); it strengthened also the cheeks of the Vincent coupling so as to sensibly increase its resistance to fracture.

The adoption of the Minet coupling by the Administration of the State Railways in 1922, abolished the use of the split link and made it possible to make connections having a very high resistance to rupture reaching 1 754 kgr. (3 860 lb.) with a 5 mm. (0.197 inch) wire [1].

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[1] Test of a 5 mm. wire joined to a screw coupling by means of an M coupling. (P. V., No. 1325, 29 November 1922, at the testing department, Malines.)

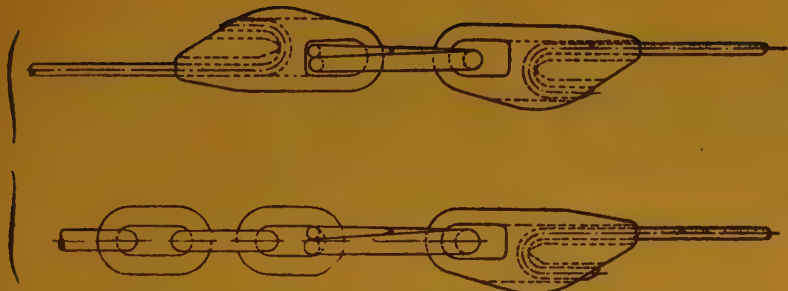

Fig. 20. — Coupling two wires together by means of two V joints and a split link, also coupling a wire to a light chain by means of a V joint and a split link.

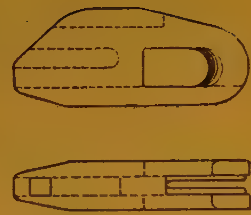

Fig. 21. Vincent coupling.

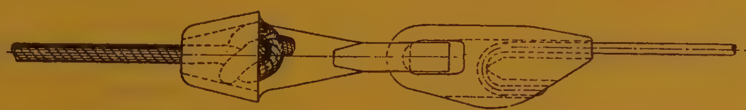

Fig. 22. — Coupling a solid wire to a stranded wire by means of a V joint and a W hook.

This coupling, made of malleable cast iron, is shown in figure 23. The end of

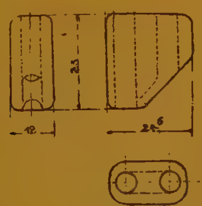

Fig. 23. — Minet coupling.

the wire to be joined up to a chain, for instance, is passed into the longest hole of the coupling and then bent round to form a loop by means of a special tool shown in figure 24; the loop thus formed is passed either into the link of the chain (fig. 25), or else into the corresponding loop of another wire (fig. 26). This hooking up being done, the second hole in the coupling joint is passed over the bent end of the wire, the extremity of which is finally hammered down into a groove made in the slanting portion of the coupling.

This bending down is done with the hammer, as shown in figure 27, care being taken to keep the loop well in position by means of special pincers (fig. 28). The loop being tightly gripped with the pincers, the bending down is easily done with two or three blows of the hammer, the joint resting on any suitable metal block.

The average resistance to rupture on eight tests with 4.19 mm. (0.165 inch) wires and light chains joined by means of M couplings has been as high as 1 121 kgr. (2 466 lb.) and up to 1 282 kgr. (2 820 lb.) for similar arrangements with 5 mm. (0.197 inch) steel wires. The tests usually ended with the breaking of the chain (1).

The average resistance of four 5 mm. (0.197 inch) steel wires attached to screwed couplings by means of an M coupling joint was 1 480 kgr. (3 256 lb.) (2).

The maximum breaking strain observed

(1) P. V. tests, Nos. 160, 18 February 1922, 313, 24 March 1922, and 904, 17 August 1922.

(2) P. V., No. 1325, 29 November 1922.

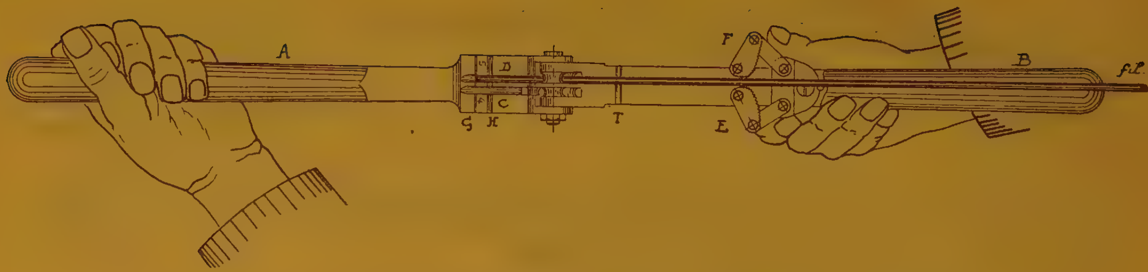

Fig. 24. — Tool for bending steel wires.
(The arms are opened out and the wire is inserted in the groove D for bending.)

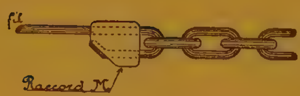

Fig. 25. — Joining a wire to a chain by means of an M coupling.

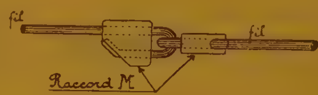

Fig. 26. — Joining two wires by means of two M couplings.

Fig. 27. — Bending the wire down in the M coupling joint groove.

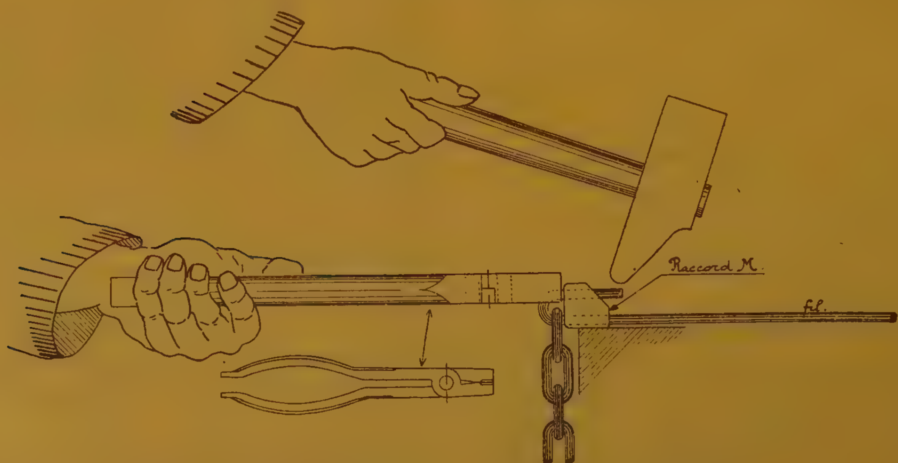

Fig. 28. — Pincers used to hold the loop when bending the wire down

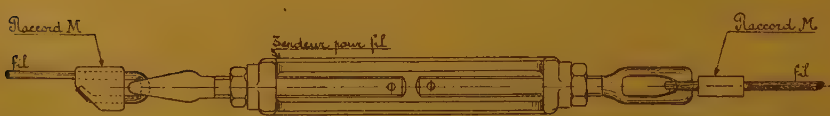

Fig. 29. — Joining two wires through the medium of a screw coupling with improved eyelets by means of two M couplings.

Explanation of French terms : Raccord M = M coupling. — Tendeur pour fil = Screw coupling for wire. – Fil = Wire.

during this test was 1 754 kgr. (3.860 lb.), as stated above.

Figure 29 shows a combination of a wire and screw coupling (the eyelets of the latter having been altered for the purpose). Figure 30 shows the joining up of a wire to a disengaging lever by means of an M coupling and solid link. Figure 31 shows the joining up of a wire to a stranded wire by means of an M coupling, a solid link and a W hook, whilst figure 32 shows the method of

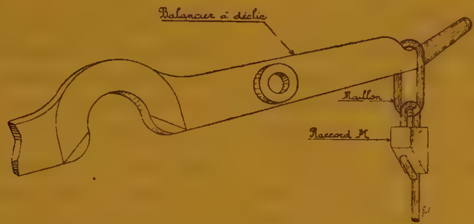

Fig. 30. — Connecting a wire to the disengaging lever by means of an M coupling joint and a solid link.

Explanation of French terms : Balancier à déclic = Disengaging lever. Maillon = Link. — Raccord M = M coupling.

Fig. 31. — Joining up a wire and stranded wire by means of an M coupling, a W hook and a solid link.

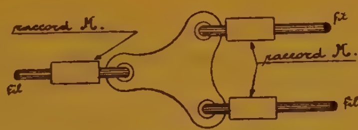

Fig. 32. — Combination of three wires connected together by means of a trefoil plate and three M couplings.

arranging a junction of transmission wire by means of a trefoil plate and three M couplings.

It might be said that the new coupling joint will cause friction between the wire or between the wire and the link of the chain. The loop of this coupling is, however, only a link inserted in the chain and submitted to precisely the same strains and causes for wear as any other link, and if we consider that the metal of the steel wire is of much greater strength and hardness than that of the chain links, it is absolutely certain that the wear in the links will be much more rapid than that of the loop.

Even if the galvanising of the latter is worn off by friction, it may be pointed out that this will leave the loop in the same condition, as far as its resistance to oxydisation is concerned, as the links forming the chain which have not been galvanised, so that all that is necessary is to regularly lubricate these loops, as should be done with the chain links.

Tool for bending the wires (fig. 24). — The end of the wire may be inserted by passing it under a roller, either into the groove C, which is made for the 4.19 mm. (0.165 inch) wire, or else as shown in the figure in groove D made for the 5 mm. (0.197 inch) wire. The gauge mark G shows the limit corresponding to the length of the loop required.

The wire having been inserted, the

handle A is brought down on to the handle B describing an angle of 180°. It should be seen that before bending the workman has hooked on the wire by means of a special arrangement EF, vulgarly called a « frog » (*grenouille*) and fixed to the handle B. This device for automatically gripping the wire is to prevent the latter slipping forward during the bending process. By this method the roller, fixed on the lever A, follows along the length of the wire in the course of bending it and so produces a loop which is rounded very regularly. If this gripping device were absent, the wire would be dragged forward during the bending process, the roller would act only on one section of the loop, which would therefore be of an irregular shape.

Compensators. — Compensators are for the purpose of maintaining a constant tension in the run of the wires when at rest whatever the variations in temperature may be.

In double wire working, either compensators with double balanceweights may be used arranged in such a way that each balanceweight acts separately on each wire, or else compensators with one balanceweight acting simultaneously on the two wires. This latter method is the one used by the Administration of the Belgian State Railways.

It is evident that a compensator with one balanceweight is based on the supposition that expansion or contraction are identical in the two transmission wires. It is therefore indispensible that the pull off wire as well as the pull to danger wire should be of exactly the same length, and further, that they follow the same course in order that they may work in identical conditions as regards the surrounding temperature.

Figure 33 shows a diagrammatic representation of a double wire arrangement fitted with a compensator with one balanceweight only.

At a portion of their course, the two

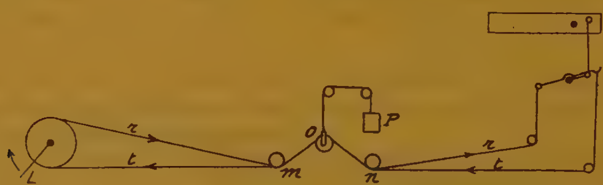

Fig. 33.

wires (pull off wire *t* and pull to danger wire *r*) pass over six pulleys fixed in couples on a same spindle. The double pulleys *m* and *n* are fixed, but the position of the double pulley *o* can change; its frame being supported by a stranded wire to the extremity of which a balanceweight P is hung, tends to pull the pulley frame upwards and thus causes a tension in the wires.

These being adjusted at a given temperature, it may be seen that any expansion due to a rise in the latter is compensated by the action of the balanceweight which comes down, pulling after it the two wires, and any contraction due to a lowering of temperature causes the balanceweight to rise.

This arrangement alone, however, is not sufficient to make a compensator work with regularity; in fact, when the signal is operated, the increased strain

momentarily created in the pull off wire would have a tendency to raise the balanceweight before the signal arm which might prevent this being placed at line clear or at least cause irregular working. It may be said, however, that this inconvenience would disappear by making use of a balanceweight sufficiently heavy to prevent its displacement under the action of the strain in working the pull off wire.

A balanceweight of this character, however, would cause excessive tension in the two wires, and it *is therefore necessary to arrange the compensator so that any action on the part of the balanceweight may be eliminated while the lever is being worked and during the whole time the signal is off.*

In most cases, the arrangement designed for compensators is based on the use of a toothed rack, which is the method employed by the Belgian State, and a description of it is given below (see fig. 34).

The two wires coming from the cabin

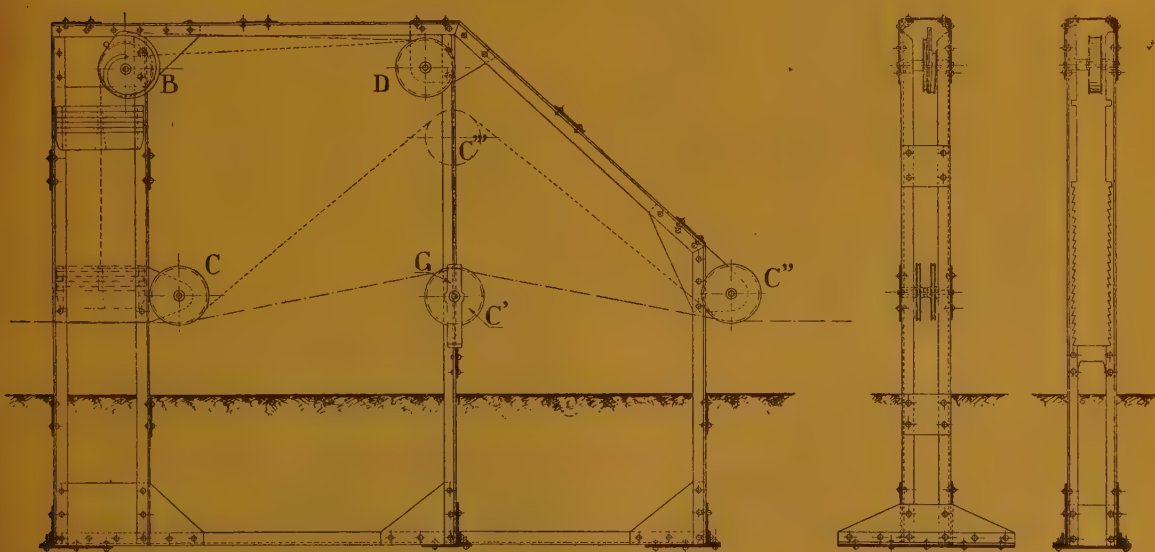

Fig. 34. — Compensator used by the Belgian State.

first pass under two guiding pulleys C fixed on the same spindle; they then pass over the top part of the grooves in pulleys C′ which are also fixed side by side on a same spindle carried by a frame G. From this point the wires proceed towards the signal, first passing under the two pulleys C″ fixed also on a same spindle.

Pulleys C and C″ are fixtures and their spindles are carried by the framework of the compensator, but pulleys C′ are not so arranged, their carrying frame being able to move vertically, and this is connected to the balanceweight by means of a steel wire cable passing over the two corner pulleys D and B. The latter is fitted with a helicoidal groove, thanks to the particular arrangement of which the action of the balanceweight varies accord-

ing to its position, and consequently according to the angle formed by the two transmission wires with the pulley C′. It is in fact obvious that in order to maintain a constant tension in the wires, the action of the balanceweight must vary according to the size of this angle.

The balanceweight is made up of loose cast iron plates, and consequently can be varied in weight according to the length of the run of the wires and their resistances.

Range of travel allowed to compensators. — Every compensator is allowed a maximum working range calculated on the extreme variations of temperature that may take place in our climate. Those of the Belgian State are constructed for variations of temperature lying between —20° and +35° C. (—4° F. and +95° F.).

Figure 35 shows diagrammatically the extreme position of the pulley frame, at C′ with —20° C. (—4° F.) of cold and C‴ with +35° C. (+95° F.) of heat.

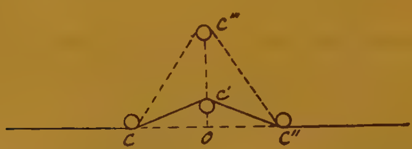

Fig. 35.

For a difference of 55° C. (99° F.) of temperature the compensator allows an extention of the wires equal to the difference between the lengths CC‴C″ and CC′C″. Now this difference is known as it results from the construction of the compensator itself, especially the dimensions C″, OC′ and the length C′C‴ which is that of the maximum stroke of the pulley frame along the racks.

Knowing 1° the maximum elongation to compensate for (resulting from the construction of the compensator); 2° the greatest variation in temperature which is supposed to be 55° C. (99° F.) and 3° the coefficient of linear expansion which is 0.000012 for steel, we can determine the working stroke of the compensator by dividing the first term by the product of the two others.

We should point out at once, however, that this purely theoretical calculation does not take into account initial strains, the existance of which, as we shall see later on, completely modify the conditions of elongation and contraction in the run of the wires.

Adjusting the compensator. — It is necessary when the compensator is fixed to determine the height of the frame carrying the pulleys C′, taking into account the temperature at the time and the variations which may occur afterwards.

The Belgian State type is constructed for controlling a length of 800 m. (875 yards) under a variation of temperature equal to 55° C. (99° F.).

Scales for adjustment are engraved on the rack along which the pulley frame moves, varying according to the length of the run of the wires for which the compensators are destined.

Figure 36 shows two adjusting scales, one of which is calculated for a length of 800 m. (875 yards) (maximum length to control), the other for a length of 400 m. (437 yards).

When adjusting, the man charged with the work takes the temperature with a thermometer and fixes the bottom part of the pulley frame to the figure giving the number of degrees centigrade which he has observed.

The pulley frame and racks. — The pulley frame G carrying the movable

pulleys C′ travels vertically between two toothed racks, the whole arrangement being for the purpose, as we have seen, to fix the pulley frame at the instant the signal is worked.

As shown in figure 37, the teeth of the

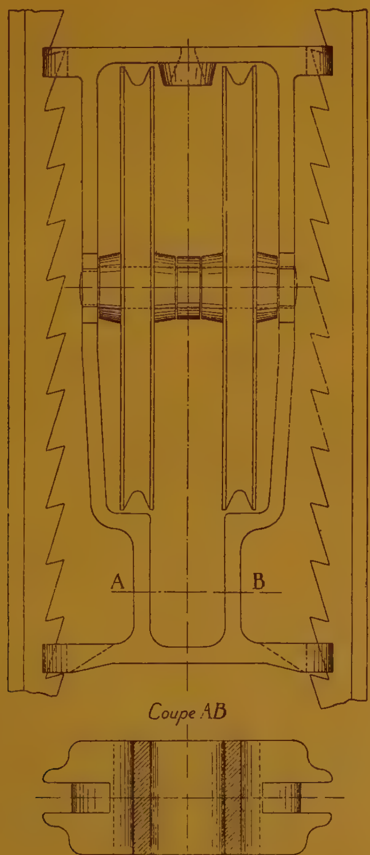

Fig. 37.
Pulley frame and racks of the Belgian State type of compensator.

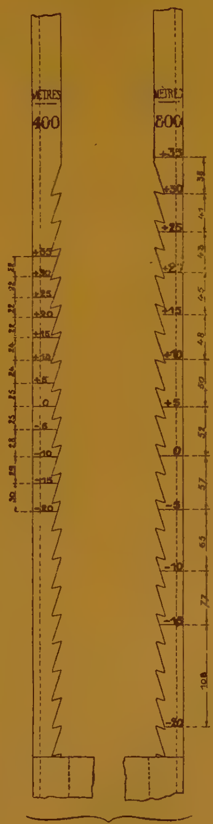

Fig. 36.
Adjusting scales.

Fig. 38.
Modified form of rack.

rack are partially engaged in notches in the pulley frame. At the bottom of the notch in the lower cross piece of the frame, the latter is cut in the form of a knife edge.

When this frame rises or falls freely (its centre line exactly following a vertical line) no catching in the rack takes place, the knife edge being some millimetres away from the projecting edges of the rack.

If for some reason or other the frame is inclined at an angle to either side, a knife edge will catch in the teeth of one of the two racks and the shape of these teeth will offer an obstacle to the descent

of the pulley frame. This could, however, continue to rise, as it would follow the successive inclined faces of the teeth without being caught by them.

The pulley frame is freely suspended by means of a cable threaded through an eyelet formed in the top of it (in the centre line of the apparatus) being guided by the cheeks of the racks passing through the notches and cannot get out of place, except by inclining sideways in a plane perpendicular to that of the pulleys.

The pulley frame is under the control of three forces; the first one is that of the balanceweight which acts along the vertical centre line from bottom to top; the two other forces are resultants of the strains in the two wires over the two pulleys; these resultants act vertically from top to bottom and pass through the centre of the pulleys; as these are symmetrical as regards the centre line of the pulley frame, the latter remains in equilibrium if these resultants are equal to one another.

This is supposed to be the case when the wires are not being worked, for then the pulley frame can freely follow its vertical motion from bottom to top, when the action of the balanceweight predominates, and from top to bottom, to the contrary, when any increased tension in the wires tends to raise the balanceweight.

When the hand lever is worked, however, the greatly increased tension produced in the pull off wire upsets the equilibrium, and the pulley frame leans sideways (the top part inclining towards the pull off wire) and the knife edge of the lower crossbar catches in the rack fixed on the side of the pull to danger wire. The frame can no longer descend, and as the surplus tension in the pull off wire tends to assist this, it is held up during the whole time the signal is showing line clear.

Inconveniences of the rack. — If the two transmission wires are theoretically at an equal tension when at rest, this is not exactly so in practice.

With double wire transmission working a disengaging lever, there is nearly always a difference of initial tension between the two wires, the pull to danger wire being generally more stressed than the pull off wire so as to keep the disengaging balance lever on its seating and prevent its rising at the moment it is worked.

This difference of tension between the two wires when at rest (it is generally less than 10 kgr. (22 lb.) is, however, sufficient to incline the pulley frame which is caught in the rack on the side of the pull off wire.

It is therefore often found in practice that the pulley frames become hooked when in a state of rest, this hooking preventing the frame from coming down, but not from rising, the result being in these cases that the compensator no longer acts upon wires contracting from cold, but continues working in case of expansion, as the form of the rack teeth does not prevent the pulley frame rising.

To sum up, this inconvenience caused by catching when at rest can only create excess tensions in the two wires, and as they are produced at the same time in both of them, they will not influence the position of the signal, which is the essential point.

It has often happened, however, that during intense cold, these excess tensions produced by the catching of the pulley frame were so great that the working of the hand lever became impossible and made it necessary to unhook the frame to relieve the situation. In these cases

the frame was so tightly jammed that a lever had to be used to release it from the rack.

Trial of a modified rack. — We endeavoured to find a solution for this inconvenience by changing the shape of the rack teeth, and the Administration of the State Railways has on trial compensators having a rack of the form shown in figure 38.

The teeth in the rack were replaced by simple waved formed ones, which we are of opinion will hold the framing up when being worked, but not while it is in a condition of rest.

The forces which bring about the slanting of the pulley frame are very different in the two cases : while being worked the difference in tension between the pull off wire and the pull to danger wire may be as high as 100 kgr. (220 lb.), while it varies from 5 to 10 kgr. (11 to 22 lb.) when at rest.

In the latter case, even when the knife edge of the pulley framing is caught in the rack, contractions resulting from a lowering of temperature have an action that is greater than the frictional resistance caused by the application of the pulley frame on to the rack under a difference of tension of 5 to 10 kgr. (11 to 22 lb.). Under these conditions, on account of the new shape of the rack, the frame is not prevented from descending when acted on in this way.

On the contrary, when the knife edge of the frame comes into contact with the rack when the hand lever is applied, the frictional resistance of the frame and rack under the action of a much greater force suffices to hold the frame up, and all the more so that the hollows of the wave shaped rack oppose to a certain extent its descent.

The altered compensators which have been in service for nearly two years have given satisfaction. The catching action is completely done away with when the system is at rest, and the working of the pulley frame perfectly corresponds with the variations in temperature.

In order to test the sensitiveness of a compensating arrangement, daily readings were taken (morning, noon and evening) during a month, of the temperature at the time and the position of the pulley frame with respect to the rack.

The diagrams showing the variations of temperature and the variations of the height of the pulley frame should be as parallel as it is possible to be.

This is the result which has been obtained during the month's observations of the working of a rack of wave form.

While working the arrangement, it has been noticed that occasionally the pulley frame made a few jumps before catching. The latter effect is perhaps not so instantaneous as with racks fitted with sharp teeth, but as far as we know, it has never interfered with the proper working of the signal arm.

Small compensators of the German type (fig. 39). — The Germans, during their occupation of the country, fitted up for signal working a large number of small compensators, the construction of which, though completely different from the one first described, is nevertheless based on the same principle. The signal department has altered the construction of these compensators by giving them a greater stability and adding certain improvements in the carrying of the pulley frame, so as to lessen the tendency of the arrangement catching when at rest. This modified compensator is shown in figure 39. A lever turning on a spindle passing through a vertically fixed channel iron which supports all the apparatus

carries the four pulleys and the balance-weight. The latter may be slipped along the lever in order to vary its power of action.

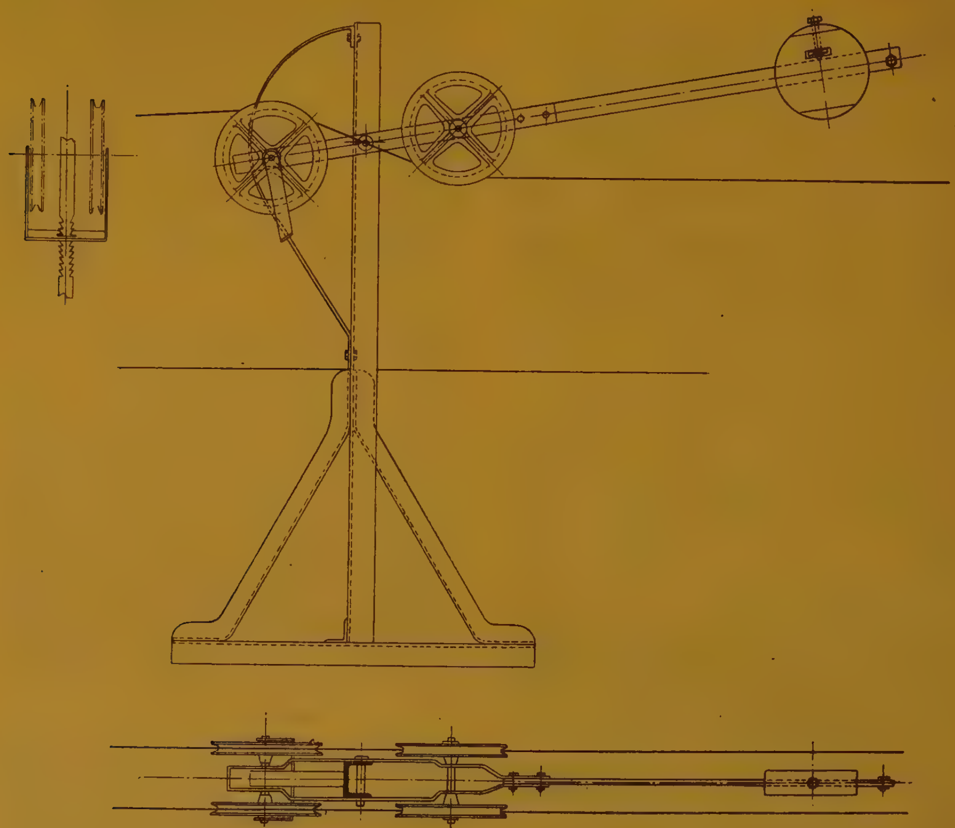

Fig. 39. — Modified German compensator.

The two pulleys fixed on the opposite end to the balanceweight turn on a spindle carrying the pulley frame which is fitted with a mortice slot through which the rack passes. When the front pulleys rise on account of the lowering of the balanceweight due to the expansion of the wires, the pulley frame rises with its mortice slipping along the rack. The sides of the mortice do not catch in the rack until a difference of tension takes place in the transmission wires. In order to allow the spindle carrying the pulley frame to incline slightly, the signal engineers have had the holes drilled in the two plates forming the carrying lever made oval.

The working of this apparatus thus altered is fairly satisfactory, but its general utility covers only a narrow range, and while the compensators of the Belgian State control a range of 800 m. (875

yards) long, these can only be usefully employed on runs of 400 m. (437 yards) at the outside.

The necessity of compensators. — If we consider a transmission arrangement 1 000 m. (1 100 yards) long adjusted to a temperature of 10° C. (50° F.), and that this may be increased to +35° C. (95° F.), we know that the elongation due to this increase of temperature of 25° C. (45° F.) will be $1\,000 \times 25 \times 0.000012 = 30$ cm., and if to this elongation (which causes a loss in the travel) we add the losses resulting, at the moment of working, from the stretch of the wire and the reduction of the sagging between the posts (of light chains), it will be seen that it is theoretically impossible to work without a compensator a signal arm controlled by this arrangement, given that the maximum loss in travel to be made good is about 30 cm. (11 5/8 inches) (difference between the 50 cm. [19 1/2 inches] travel at the hand lever and that of 20 cm. [7 7/8 inches] at the disengaging lever). It is, however, perfectly possible to work a signal arm 1 000 m. (1 100 yards) away without a compensator and without even being obliged to make a reduction of the travel at the foot of the signal post.

It is known that the elongation of a wire under tension is not calculated, as mentioned above, as the increases in temperature have the effect of diminishing the initial strains before producing any elongation.

During the testing of a set of points, worked by a double wire transmission nearly 600 m. (650 yards) long put down with an initial tension of 70 kgr. (154 lb.) *without a compensator*, we were not able to trace any perceptible losses in the travel of the wires during our daily observations, in spite of variations in the temperature, these having the effect of influencing the initial tensions only.

In Holland, compensators are not generally used with transmission wires of signals less than 1 000 m. (1 100 yards) long or with those for points of a length sometimes as much as 550 m. (600 yards). Compensators have been generally abolished in Austria and in Hungary. In certain parts of Germany, notably in Wurtemberg, advance signals are sometimes worked without compensators at a distance of 1 000 m. (1 100 yards).

The effects of expansion are overcome by increasing the initial tensions and adjusting the transmission wires twice a year : at the commencement of Winter and at the beginning of Spring.

The Administration of the Belgian State Railways has also begun to abolish compensators on short lengths. For trial purposes, compensators fixed to certain transmission wires for signals less than 800 m. (875 yards) away and for points less than 500 m. (550 yards) away have been removed. The points chosen for these tests being only those in which the train enters by the heel.

Up to now no inconvenience has been noticed due to doing away with these compensators.

We are of opinion, however, that for three position signals where a very fine adjustment of the transmission wires is necessary, it is prudent to fix compensators in any arrangement longer than 600 m. (650 yards).

Compensators for wires working points. — We have seen the effect of a compensator on disengaging balance levers in case the pull to danger wire breaks. This action of the compensator may cause trouble in case the wire working a set of points breaks; in fact, if the rupture takes place in the wire having pulled

the points over in the preceding operation, the whole force of the compensator's balanceweight being brought suddenly on to the other wire may completely reverse the operating pulley and the set of points, or else bring about a partial reversing of the operating pulley and so cause a partial displacement of the points.

It must not be thought, however, that abolishing the compensator in wire transmissions working points will remove all danger resulting from a broken wire, in fact, the suppression of the compensator can only be done by introducing high initial tensions in the wires, and in case of the wire breaking in the conditions mentioned above, the excessive tension in the wire remaining intact will tend to turn the operating pulley, evidently less violently than with the balanceweight, but nevertheless sufficiently to put the points out of place and so cause an accident.

In order to avoid anything of this nature happening, the Administration of the Belgian State Railways have issued the following rules for all cases in which points are worked by double wire and entered into from the toe : 1° the electrical repetition of the position of the points on which the reversing of the route lever is made subordinate and consequently that of the signal lever; 2°, the mechanical interlocking of the points by means of a circular bolt worked by an independent lever.

It is in fact evident that the electrical repetition of the position of the points would be useless if the wire broke when the corresponding signal was showing line clear.

Adjusting screw couplings. — The screw coupling for adjusting transmission wires used by the Administration of the Belgian State Railways is shown in figure 40.

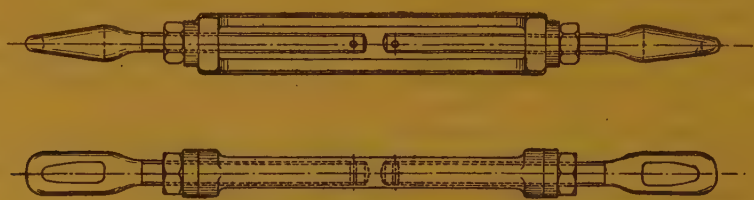

Fig. 40. — Adjusting screw coupling for transmission wires.

These screw couplings, made from stamped steel, were generally attached to the wires by means of a V joint and a split link, but on account of the latter being done away with and the M joint adopted, the shape of the eyelets in the screw coupling have been slightly altered.

These screw couplings are inserted in the run of each wire working signals : 1° at the signal itself in the vertical portion of the wire at a man's height; 2° in the proximity of compensators; 3° in the proximity of travel reducers.

Formerly these couplings were also placed under the signal boxes near the operating lever, but in this position were found to do more harm than good, so were abolished, for when anything went wrong with a transmission wire, the men, in order to avoid having to occasionally go some distance to put it right, got into the habit of adjusting the screw coupling nearest the operating lever, where they could not be at all certain what effect this had on the signal itself. It often happened therefore that this method of

adjustment only made matters worse instead of better.

In order to avoid the position of the screw coupling being altered by the men charged with the adjustment of the transmission wires, the two rods containing the eyelets are drilled at their idle ends with a hole through which a metallic wire is passed, and this is rolled round the frame of the device, its ends being fixed by means of a lead seal. The pliers used for this purpose leave a special mark, so that the man who has done the work may be afterwards recognised.

It is therefore impossible to alter the respective positions of the screwed rods without breaking the lead seal. This sealing of screw couplings in the case of wires working points is obligatory, and in our opinion it should be equally so in the case of signals, especially three-position signals.

The two screwed rods of these couplings are fitted with check nuts with the object of preventing any turning of the nut by vibration.

Travel reducing lever with adjustable disengaging hook (fig. 41). — The travel of an operating lever being 50 cm. (19 1/2 inches) and that of the wire up to the disengaging balance lever 20 cm. (7 7/8 inches), it may be seen that if in extreme cases it is admitted that there is a loss of 30 cm. (11 5/8 inches) in the travel of very long runs at the time of operating, this is not the case when shorter wires are used.

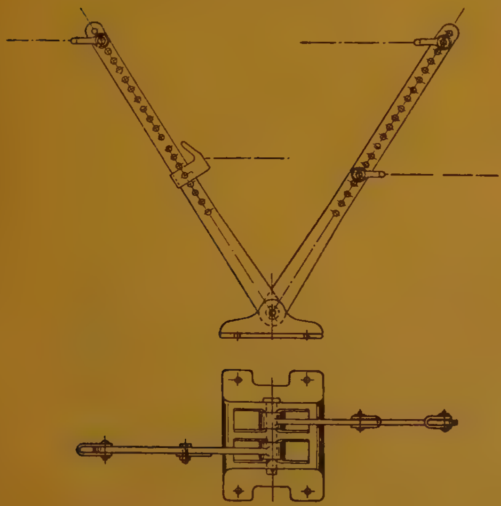

Fig. 41. — Travel reducing lever with adjustable disengaging hook.

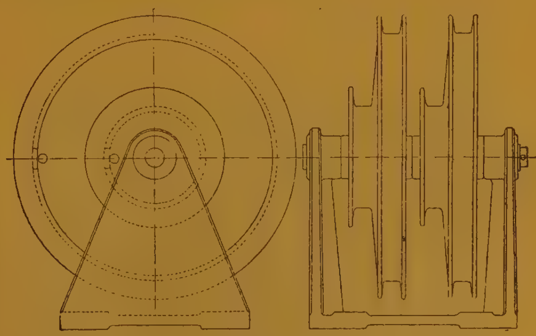

Fig. 41*ter*. Vertical carrier fitted with two differential pulleys.

If therefore it is desirable to obtain a suitable initial tension in the wires in order to make the regular working of the signals certain, as a general rule it will be necessary to *shorten the travel of the transmission wires at some part of their run.*

The losses in the travel of transmission wires vary according to the length and weight of the wire, the distance between the carrying posts, the number of conducting pulleys, the weight of the signal arm, the various frictional resistances, etc. It is not possible to determine beforehand the losses of travel that may be allowed for any particular length that

may be desired for the purpose in view, and the amount of reduction in the travel is determined by a practical test after the transmission wires have been given a good initial tension.

Up till quite lately the Administration of the Belgian State Railways used exclusively differential pulleys (fig. 41*ter*) in order to obtain the reduction of travel required in the transmission wires. These pulleys were fixed at the foot of the semaphore, one differential pulley being inserted in each wire.

There are two inconveniences attached to the use of these pulleys : 1° it allows only one degree of reduction to be made in the travel (about 2 to 1) when circumstances might arise requiring a varied graduation in the reducing scale; 2° the differential pulley might prevent the upsetting of the disengaging balance lever in case the pull to danger wire breaks, because occasionally it prevents an insufficient unrolling of this wire.

At the present time, travel reducing levers, as shown in figure 41, have been substituted for differential pulleys. A travel reducing lever is inserted in each wire as near to the signal as possible (fig. 41*bis*).

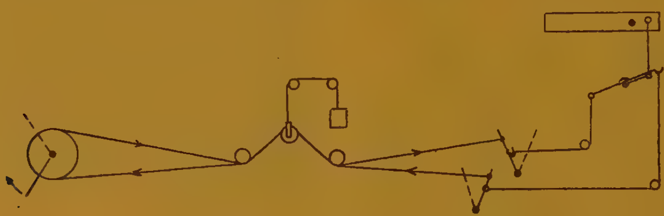

Fig. 41*bis*.

The workman responsible for the adjustment chooses amongst the holes drilled in the faces of the reducing levers those suitable for the amount of travel required and for the necessary tension.

The adjustable disengaging hook, to which is attached that part of the pull to danger wire proceeding to the disengaging lever, allows the unhooking of this wire in case that part lying between the hand lever and the travel reducing lever breaks. It is evident tha' in this eventuality the tension in the pull off wire will drag the reducing lever fitted with the disengaging hook towards the signal, and this lever, no longer held by the broken pull to danger wire, falls to the ground, and the other portion of this wire, by unhooking itself, allows the disengaging lever to act as it is designed to do.

Adjustment of the transmission wires. — These wires should be adjusted so that; 1° a complete travel of the signal arm may be obtained in both directions and whatever variations of temperature there may be, and 2° the use of unnecessary force on the part of the signalman when working it may be avoided.

To obtain this double object it is necessary to :

1° Reduce as much as possible the losses in the travel at the time of operating;

2° Reduce resistances, especially those of a frictional nature.

Losses in travel which are produced at the time of operating may be due :

1° to the stretch caused in the pull off wire by the working tension arising at the moment the signal arm is placed at

line clear; during this operation the pull to danger wire becomes slack.

Conversely, when the signal arm is put back to danger, the strain occurs in the pull to danger wire, it is the latter which elongates and the pull off wire, is slacked;

2° to the loss of travel produced in the pull off wire at the time of putting the signal to line clear and resulting from the tightening up the successive saggings of the wire between its supports.

The same action takes place in the pull to danger wire when the signal is replaced to danger;

3° the elongation of the two wires due to increases in temperature;

4° the displacement of the transmission wires either due to the want of stability of certain of the fittings, such as the tressels supporting conducting pulleys, posts, compensators, etc., or else to an excessive amount of play which sometimes occurs at the pulley spindles.

1° The elastic elongation may be calculated from the formula $a = \frac{T}{S} \times \frac{L}{E}$, in which a represents the total elongation; T, the tension due to the pull of the lever; S, cross section of the wire; L, its length and E, the modulus of elasticity of the steel. (It is presumed that all these runs are fitted with steel wires, chains or stranded wire inserted in the runs being neglected.)

In a transmission system of fixed length with a wire of standard diameter, the only variable quantity in this formula is T.

This tension T which produces the elongation is equal to the difference between the working tension T′ and the initial tension T″.

It is found therefore that the losses in travel at the time of operating the apparatus will be so much the less as the initial tension is greater, which is *a priori* evident.

On the other hand, the working tension depends on numerous and variable conditions, amongst which may be mentioned : the weight of the signal arm and the screens; the frictional resistances at the conducting pulleys, guide pulleys and joints of various kinds; the state of the various parts (want of lubrication); atmospheric conditions, such as wind, snow, frost and cold.

All these points show the importance of keeping the working parts of the arrangement in good condition if we wish to avoid abnormal strain in operating and useless losses in the travel of the wires.

We will refer in passing to a phenomenon that is well known to all those interested in signalling. This is the influence the working of the hand lever has, for it often happens that when a signalman works this lever sharply when operating a signal some distance away, he will always manage to bring the arm fully down to the stop for line clear, whilst another signalman less experienced and not so strong may fail to do so. This pecularity is due to the fact that the sharp starting of the lever in the first case immediately implants a certain speed in the transmission wire which communicates at once, to the various working parts of the system, a live force which is added to the effort made by the signalman.

We should strongly point out, however, that the adjustment of the wires must be based on no such consideration, but so that the signal is completely controlled by the hand lever in whatever way the necessary power may be applied to it;

2° The losses in the travel due to the tightening of the sag in the wires between the supporting posts at the moment of operating may be determined by calcul-

ating the curve lengths of the wire when at rest and when in action.

The curve lengths are calculated from the formula $b + \frac{b^3p^2}{24\,T^2}$ in which b represents the distance between the carrying posts, p, the weight per metre run of the wire, and T, the tension in the latter.

The variation in length of one curve between two successive carrying posts will therefore be :

$$\left(b + \frac{b^3p^2}{24\,T''^2}\right) - \left(b + \frac{b^3p^2}{24\,T'^2}\right),$$

T′ represents the working tension and T″ the initial tension when at rest. The total loss in travel over the whole length is obtained by multiplying the result thus found by the number of spacings of the posts.

It will be seen that for a wire of a given diameter, the losses in its travel are so much smaller as the spacing between the posts is decreased, the initial tension in the wire is greater, and the tension due to operating is smaller.

Here the question may be asked what spacing should be allowed between the posts; there are, however, no fixed rules relating to the subject, but in the desire to avoid these losses in the travel of the wire, it is necessary to place the posts as close as possible to one another; on the other hand it has to be taken into consideration that the more the number of posts is increased, the greater becomes the friction.

In the case of working sets of points where the necessity of avoiding travel losses must take precedence over any other consideration, the spacing should never exceed 10 m. (33 feet).

When transmission wires for signals are long and winding, this space of 10 m. (33 feet) may also be adopted, but in ordinary runs a spacing of 12 m. (39 ft. 5 in.) is a general practice and even 15 m. (49 feet) where the length of the run is short and in a straight line;

3° Losses in travel due to temperature expansion have been discussed in the chapter « *Necessity for compensators* » and we have seen that they can be substantially reduced by giving them a sufficiently high initial tension when put down;

4° Losses in the travel due to the displacement of certain of the contrivances in the run may be avoided if these are suitably looked after, and we will go into this subject later on.

To sum up, independently of the question of keeping the various parts in good repair, the requirements of a properly adjusted transmission system may be formulated as follows : « *high initial tension and reduction of the travel at the foot of the signal by means of a travel reducing gear* ».

It will be understood that with a subject, the factors of which are so numerous and variable, it is not possible to give precise rules as regards the amount of initial tension that should be given, and all the less so because the use of a dynamometer for adjusting the tensions when the wires are at rest has not yet been introduced as far as we are concerned.

All that we can say is that the initial tension should be such that, without making the working of the signals too hard for the signalman, the travel of the principal transmission wires measured up to the reducer should be as long as possible, and consequently its reduction at this contrivance should be as long as possible, the travel of the wire between the reducer and the disengaging lever being uniformly 200 mm. 7 7/8 inches).

It is worth while mentioning that with every new installation, any adjustment

made at starting can never be considered as definitive and has to be checked and often altered for some time afterwards, as new wires are often somewhat out of shape, which improve by degrees and only become in perfect condition after working for some time.

When testing afterwards, it is best to choose as hot a day as possible so as to make certain that the travel of the compensating lever acts to its full extent in both directions in whatever way the hand lever may be worked.

Upkeep of wire transmissions. — The upkeep of transmission wires is done with the object of reducing losses in the travel, frictional resistance, and to make certain at the same time that the working parts are in good order.

It should be seen that the foundations of the pulley frames are perfectly stable, which may be observed at the time the signals are worked, no movement whatever should be allowed to take place when this is happening. In order to obtain this stability, the wooden foundation pieces should be properly rammed up tightly, and any piece showing signs of decay at the holding down bolts should be replaced. The stability of the foundation posts should also be checked.

The guide pulleys should be fixed in such a way that the chain moves as far as possible in the same path as the centre of the pulley groove, so as to avoid friction between the chain and the sides of the groove. In order to gain this object, the level of the last post preceding the guide pulley is lowered.

The alignment of the short posts carrying the guide pulleys for the wires should be accurately staked out before they are fixed, and their levelling should also be done either directly, or simply by comparison with the neighbouring rail. The nuts of the bolts holding these pulleys should be well tightened, the pulleys being placed vertically in straight runs and inclined according to circumstances when they have to act as angle pulleys round curves.

The frictional resistances of the guide pulleys properly so called are as follows :

a) Friction between the pulley sheave and its frame; care should be taken to see on delivery that the bosses of the pulley faces and the corresponding parts of the frame have been properly and truly machined;

b) Friction of the pulley on its pin; these pins should be truly turned and the corresponding holes in the pulleys accurately bored. As soon as a pin is found to have any perceptible play, the hole in the pulley should be bored out to a larger diameter 1, 2 or 3 mm. (0.039, 0.078 or 0.117 inch) and the pin replaced by another of larger diameter. For this purpose a series of spare pins are kept in stock, 1, 2 and 3 mm. larger in diameter than the original pin;

c) Friction of the light chain in its pulley groove; to reduce this friction it should be seen that the chain is of correct size.

These frictional resistances being proportional to the length of the chain lying in the groove, no conducting chain should be fixed at an angle more acute than 90°;

d) Friction of links between themselves. In order to reduce this as much as possible, the chains should be regularly and thoroughly lubricated in the same way as the chain pulley spindles and those of the wire wheels.

The lubricant used for the upkeep of these transmission arrangements consists of a mixture of petrol and unrefined colza oil.

CHAPTER II.

Semaphores of the new method of signalling.

On all lines not yet fitted with the new method of signalling, the semaphore arm rising to an angle of 45° when giving line clear is made use of. So that drivers may know that the semaphores are of the old kind and avoid confusing them with those of the new signal system in which the arm is placed vertically when giving line clear, the arms of the old kind are fitted with a sheet iron ring. It is in fact necessary that during this transitory period, confusion of any kind should be avoided, because the position of the arm of an absolute stop or home signal which is raised to 45° gives different indications in the two cases.

Semaphores of the old pattern. — These are the *universal transformable semaphores*, the description of which appeared in the *International Railway Congress Association Bulletin* for October 1909, p. 1075. A lighter post was used for semaphores constructed later on which could not be transformed, but the working parts shown in figure 42 have remained the same.

The motion is communicated to the arm by means of a disengaging balance lever working with a crank which is connected directly to the signal arm in such a way as to make it take an inclined position of 45° after the disengaging balance lever has been acted upon.

The lamp is placed to the left of the post and the spectacle plate carrying the red and Isly blue (giving the green light) roundels moves behind the arm. The front spectacle as well as the back screen (serving to cover the white light at the back when the arm is giving line clear), are fixed on the same shaft and turn in pedestals forming part of the support itself of the lamp.

The arm directly communicates its motion to the screen shaft by means of a coupling rod fixed to the back face of the arm and to a crank fitted with a pin and keyed on to the screen shaft. The pin of the crank slides in a slot in the coupling rod and the front double spectacle as well as the back single spectacle naturally follow, with a slight lag, the motion of the signal arm.

The travel of the latter is limited by stops, and in case of unhooking of the pull off wire (resulting as we have already seen from the breaking of the pull to danger wire), the weight of the arm, being in the line clear position, causes it to fall to danger without the assistance of any balanceweight.

These semaphores are not fitted with any arrangement for lowering or raising the lamp, but the latter is placed on a fixed support, and by means of a ladder leading to a platform, the lamps and mechanical apparatus can be attended to.

Semaphores of the new type fitted with an absolute danger or home signal and rising to a vertical position to give line clear (fig. 43). — The arms and mechanism for working the new method of signalling are fixed either on the old metal posts or else on new posts made in reinforced concrete.

Absolute danger arm working from 0 to 90°. — Figure 43 shows an arm working from 0 to 90° and fixed on to a metallic post.

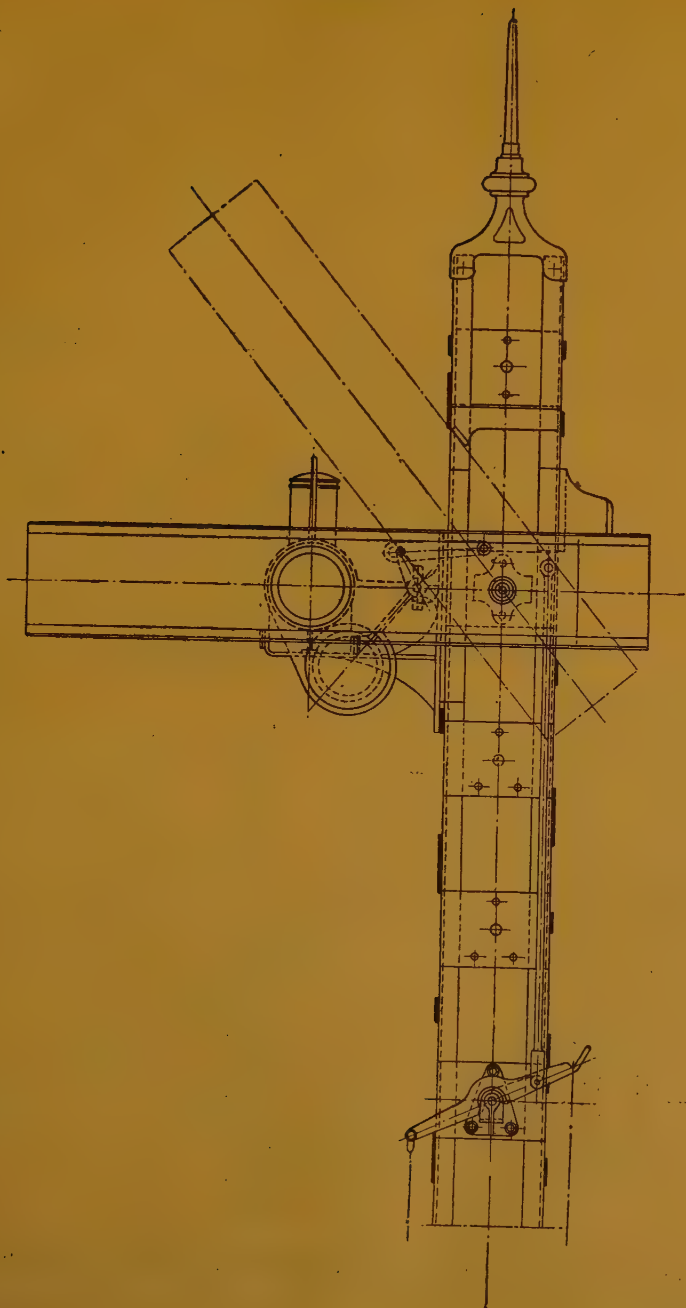

Fig. 42. — Old type semaphore (Belgian State) with arm rising to 45°.

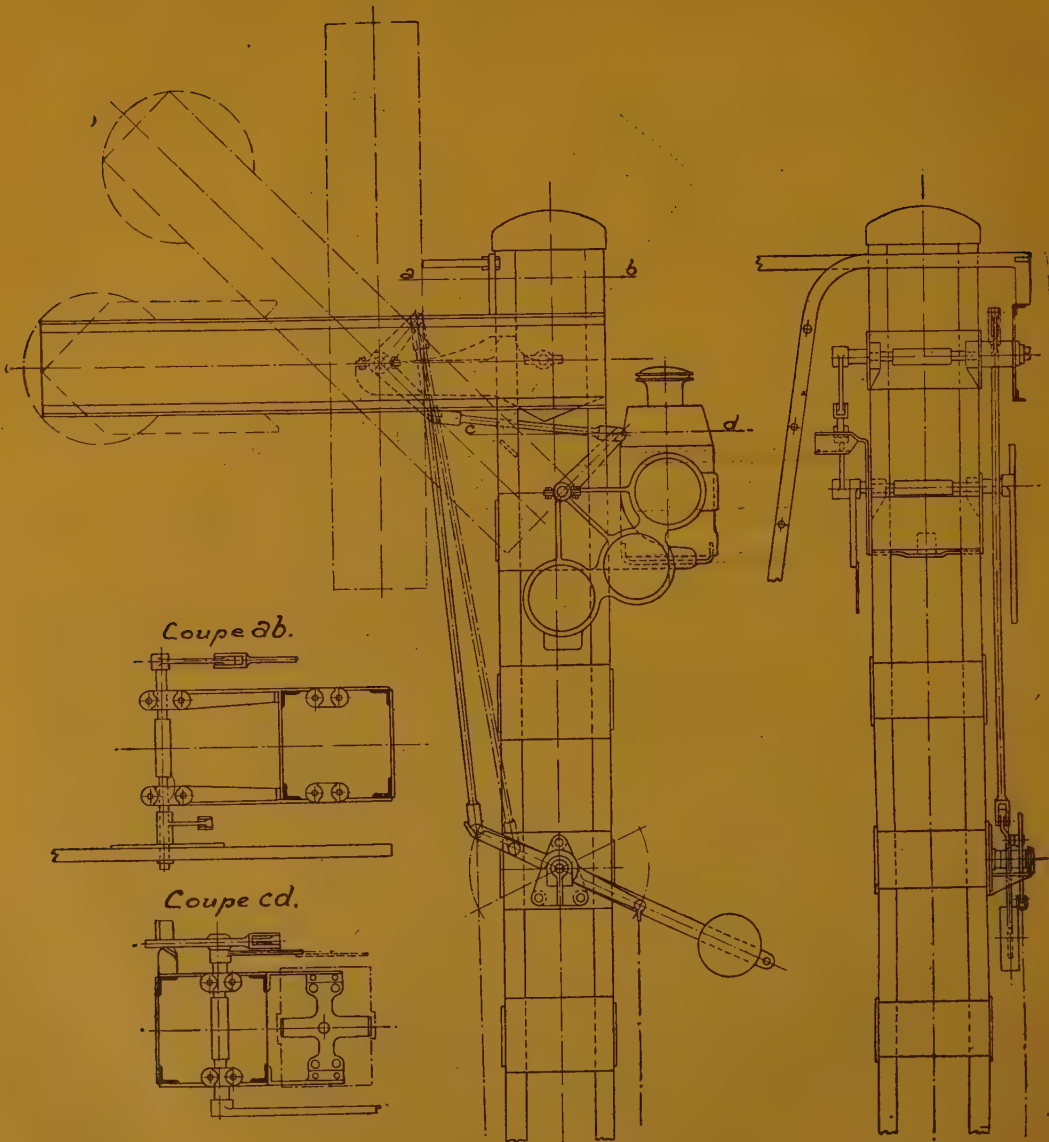

Fig. 43. — New type semaphore (Belgian State) with arm that rises vertically (0-90°).

(The fitting up can be temporarily altered so that the working may be between 0-45° instead of 0-90°).

The type called « balanced arm » has been adopted after a trial had been made for some time with that called « decentred arm » in which the rotating spindle was fixed in the centre line of the post.

As shown in the figure, the spindle on which the balanced arm rotates, the centre line of which is 457 mm. (18 inches) from the centre line of the post, is supported by two wing plates in cast steel and fixed to the angles of the post by means of three bolts.

Pedestals with caps are fitted to these wing pieces to carry the shaft which rotates the arm and also for contingencies, room being allowed for fixing a second spindle passing through the post and which is used in certain cases which will be mentioned later on.

We may point out in passing that the necessity of having two independent wing plates (instead of one wing plate only, of suitable form, which would have prevented the possibility of their getting out of line with one another) is due to the fact that these arrangements must be fixed to old posts of various sections.

The signal arm is fixed to the end of the rotating spindle by means of a square socket and a nut screwed on to the end of the spindle. The crank which works the arm and is placed immediately behind it is also fixed on the square end of the spindle.

On the back extremity of this spindle, a second crank is keyed making an angle of 90° with the crank working the arm and joined by means of a coupling rod to the crank keyed on to the shaft working the screens.

This working shaft which passes through the post turns in the brackets of two cast steel wing plates fixed like the two others on opposite sides of the post; these are joined together by means of four bolts connecting each wing plate to the angles of the post, and are joined together by means of a cross piece which serves as a support for the lamp.

From this it will be seen that the light shows on the right side of the post instead of on the left side as with the old type of semaphore.

The spindle working the screens is shaped into a square at both end and carries at its front extremity the malleable cast iron triple spectacle, and on its back extremity a screen which masks the white light behind as soon as the arm begins to move upwards. The spectacle therefore follows exactly the motion of the arm, and in case of ordinary working from 0 to 90°, the top and middle roundels are each glazed red and the bottom roundel with an Isley blue glass giving a green colour.

The green light does not therefore begin to appear until the signal arm has travelled a distance corresponding to over 60°, and in reality this green light is only clearly seen from a distance at the instant the arm has travelled through an angle of about 80°. It is obvious therefore that the green light should be made visible at the end of the stroke of the signal, so that if any disarrangement takes place, which might produce a doubtful position of the latter, the result is that the red light is shown calling for a stop.

The travel of the spectacle is limited by a stop fixed on one of the corner angles of the post which prevents damage to the spectacle by rough handling in working it.

The disengaging balance lever has been kept in this arrangement, and it is through it that the balanceweight lever to which it is connected is worked.

The distance through which the signal arm travels having been doubled, the balance lever working in conjunction with

the disengaging balance lever has necessarily had to be made longer and is joined by means of a coupling rod to the crank keyed on to the spindle which rotates the signal arm.

The balanceweight of the balance lever connected to the disengaging balance lever is only provided for the purpose of bringing the arm back to danger in case the pull to danger wire breaks and the pull off wire is unhooked. When the arm is standing at 90°, the vertical passing through its centre of gravity is not absolutely identical with that passing through the centre of rotation. The distance apart, however, of these two verticals which forms the leverage of the weight of the arm applied at its centre of gravity is, however, of small importance, and it is to be feared that the frictional resistance of the various joints may in some cases interfere with the falling of the signal arm. So as to help this automatic fall of the signal, a balanceweight has been fitted to the end of the disengaging balance lever crank which has been lengthened for this purpose, and being raised when the arm is in a vertical position has always a tendency to bring the latter to danger.

The coupling rod working the arm is no longer attached, as on the old semaphores, to the disengaging balance lever and the crank as well, but only to the latter, which makes it easier for the lever to be displaced when required by circumstances.

The travel of the arm from 0 to 90° is limited by a stop fixed on one of the corner angles of the post above the arm.

Balanced arm used for working between 0 and 45°. — If it is desired to construct by means of spare parts belonging to the 0 to 90° signal arms just described, a semaphore arm working from 0 to 45° as in the old method of signalling, all that is necessary will be to limit the travel of the arm to 45° by means of a stop fixed on one of the corner angles of the post underneath the arm. A sheet iron ring is then placed at the end of the arm and the red glass fixed in the middle of the spectacle is replaced by one of Isly blue, the bottom glass being hidden by means of a sheet iron plate. Finally, it is evident that the travel of the crank working the arm must be halved, and for this purpose the rod connecting the two together must be fixed, instead of at the end of the counterweight lever, at a position half way between it and the rotating spindle so as to obtain the requisite reduction of travel.

Concrete semaphores. — The same working appliances have been fixed on posts made in reinforced concrete. The wing brackets carrying the arms are joined together and to the post by means of bolts passing through the latter in suitably arranged holes. A similar arrangement is made for carrying the screen spindle. The supports for the disengaging levers, as well as the stops for the arms, are also fixed to the body of the post by means of bolts.

Finding in practice that the top wing brackets fixed on concrete posts had a tendency to shift from their position, a new type of wing bracket is now being used, the cheeks of which are made in one piece, and the old kind still in use has been strengthened by means of stays joining the plates together and rigidly connecting them with the wing brackets which carry the screen spindle.

Balance levers for over-travel, Cesar's system. — The disengaging balance lever has no over-travel either before or after

the working of the arm, it therefore follows that to reach an exactly vertical position depends entirely on the tension in the wire pulling it.

In a general way, balanced arms always come sharply to their horizontal or vertical position, thanks to the careful adjustment of the whole system. It happens, however, that with long or winding runs, the arm put to the line clear position remains slightly at an angle, or else having been violently thrown by a sharp pull against its stop, it takes a slightly inclined position on account of the reaction caused by this stop and a slight slackness in the pulling off wire.

In similar cases, in place of the ordinary disengaging balance lever, successful use has been made of the over-travel lever shown in figure 44.

This is composed of a disengaging balance lever C to which are attached the two transmission wires and coupled by means of a pin at G to a lever B fitted with a balanceweight D, and also swivels on a boss on lever A, one end of which is coupled to the rod working the signal arm, whilst the other end passes through a slot made in the balanceweight D which serves as guide. The lever A is also jointed at E to the lever B.

Figure 44 shows its different phases when at work : when the wires are being operated, the disengaging balance lever swivels round the point O, transmitting its motion to lever B through the medium of spindle G.

A tendency therefore is given to lever B to turn round the spingle E, but is prevented by the fact that the loading of the balanceweight preponderates over the force required to raise the arm.

Balance lever B therefore carries forward the lever A through the medium of spindle E until the arm comes in contact with its stop. Up to now the disengaging lever has not come to the end of its travel, and the lever A is stopped because the signal arm is in contact with its stop; point E therefore becomes stationary and the motion which the disengaging balance lever continues to impart to the lever B forces the latter with its balanceweight to rise in turning round spindle E.

This last phase of the operation, during which lever B and its balanceweight D change their position in relation to the lever A, forms what is called the over-travel and prevents, within certain limits, the position of the signal arm being influenced by any inaccuracy that may happen to be in the run of the wires and which is taken up by the variation in the distance the balanceweight is raised.

Two-position distance arms (0 to 90° or 0 to 45°). — These arms are worked by the same mechanical contrivances as the home signals 0 to 90° and 0 to 45°.

The form of the arm is a simple modification made by adding to its end a piece of sheet iron cut in the form of an arrow (see fig. 43). When working in the position 0 to 90°, the triple spectacle is fitted with a yellow roundel in the top and middle frames and an Isly blue roundel in the bottom frame.

In the case of a distant signal working only from 0 to 45°, the mechanical parts are altered as mentioned above for the ordinary signal arms, though instead of an ordinary lamp, a lamp showing two lights is used and the triple spectacle is completed as shown in figure 45. From this it will be seen that the top and bottom roundels of the triple spectacles are fitted with projecting tabs through which holes are drilled to allow sheet iron plates to be riveted to them so as to lengthen them in order to mask if necessary the second light of the lamp. A circle of

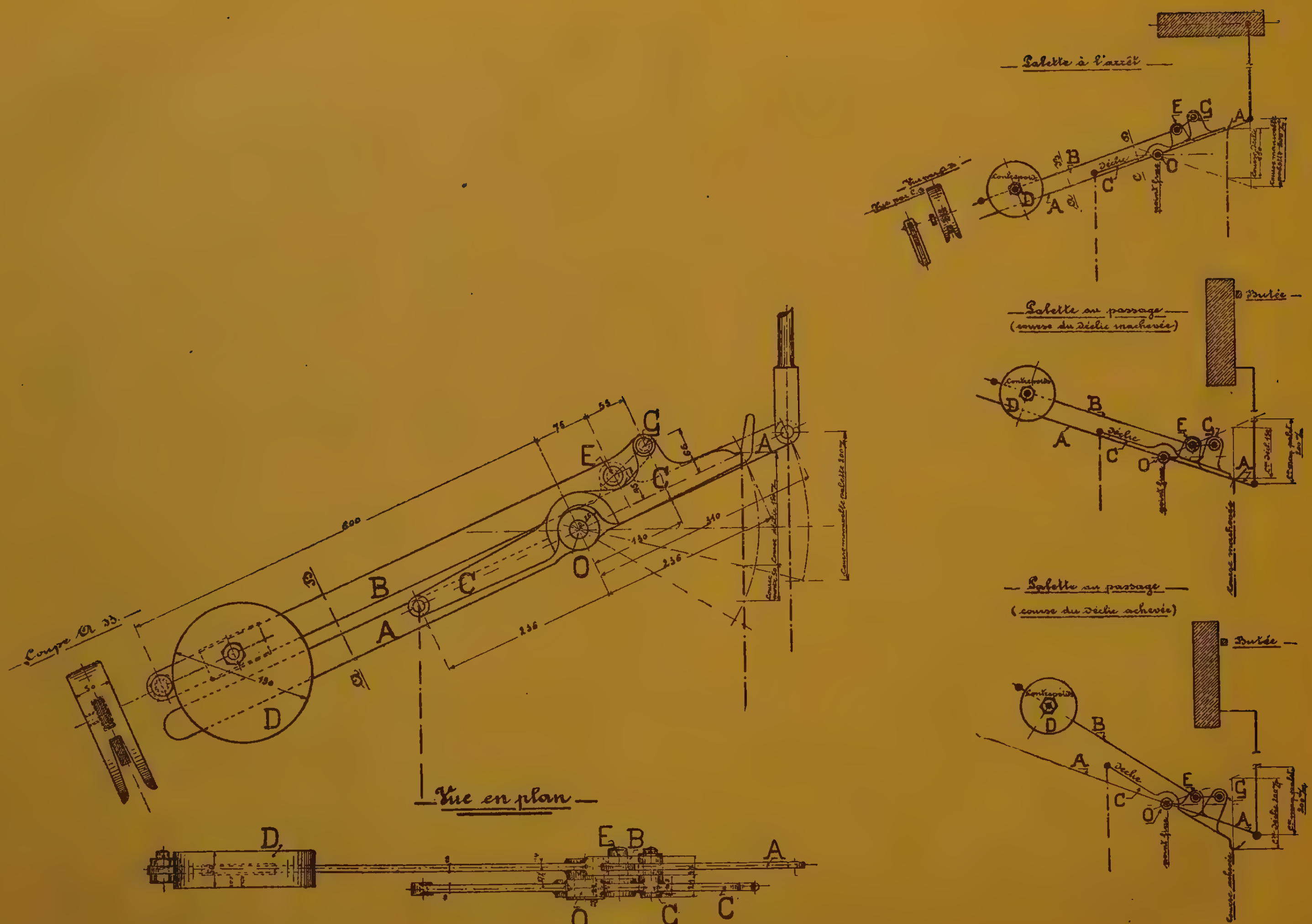

Fig. 44. — Cesar's over-travel balance lever.

sheet iron is therefore fixed to the top glass frame of the triple spectacle which masks the reflected light given from the lamp when the arm is at danger. When the arm is standing at 45°, the second lens of the spectacle fitted with a yellow glass,

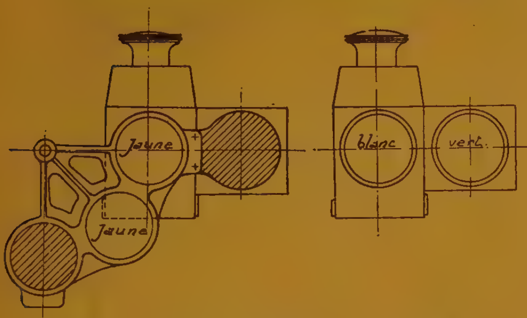

Fig. 45. — Triple spectacle and lamp for distant signal 0-45°.

Explanation of French terms : Jaune = Yellow. Blanc = White. — Vert = Green.

comes in front of the direct light coming from the lamp, whilst the light reflected from the latter being unmasked by the triple spectacle appears green, as the glass of the lamp placed before this reflected light is in this case of Isly blue colour.

Note. — The mechanical devices described above allow us therefore to obtain the various positions required for signals which are represented in figure 46 by the conventional signs adopted for the purpose of getting out projects for signal arrangements.

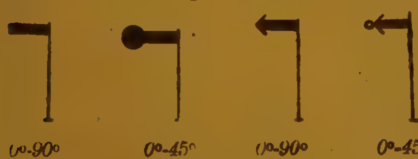

Fig. 46.

* * *

The working of three-position home signals necessitates the use of special arrangements based on the slot principle, but before considering these arrangements, we think it better to describe the various slot systems used by the Administration of the State Railways.

Slotting of signals. — The object of using a slot with a signal is in order to put this signal under the control of two signal cabins so that it cannot be placed at the line clear position except by agreement of the two cabins, and that it can be placed at danger by one of them, no matter which.

We will give the name of *local cabin* to the one that is generally nearest to the signal in the radius of action in which this signal is fixed; the other cabin will be called the *slot cabin.*

Placing the signal at line clear can only be effected after operating two levers, the first being in the local cabin, and the second in the slot cabin.

The Administration of the Belgian State Railways uses three types of slots : the link slot, Cesar's rotary slot, and the electric disengager (replacer) of the « Ateliers de Constructions électriques de Charleroi ».

The link slot. — Figure 47 shows a signal arm working from 0 to 90° and slotted by means of an arrangement called the link slot; figures 48, 49 and 50 show diagrammatically the method by which it is operated.

Each of the wires proceeding from the local cabin and from the slot cabin work a disengaging balance lever connected to a counterweighted balance lever. The corresponding balance lever at the local cabin works a coupling rod A, whilst the corresponding balance lever at the slot

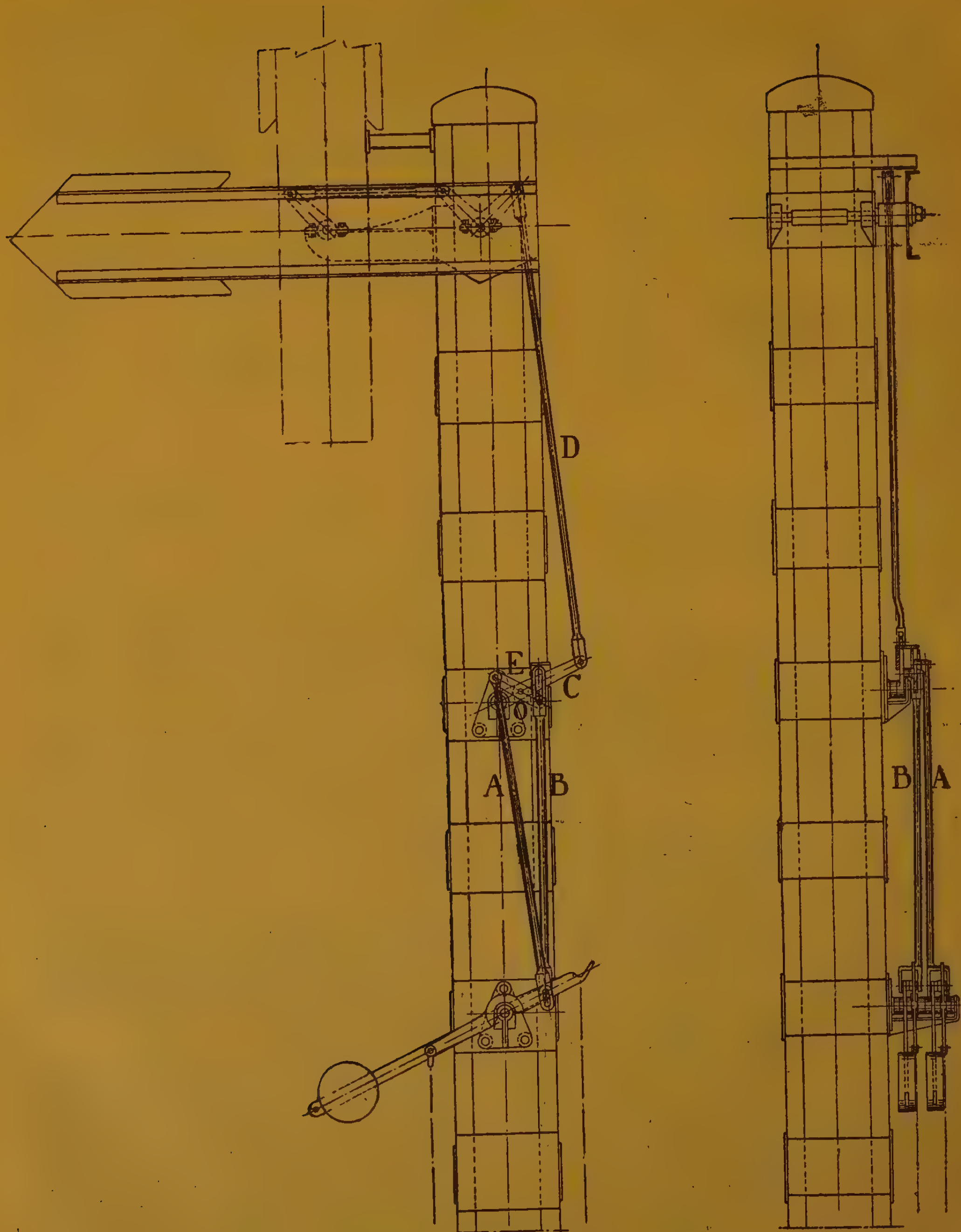

Fig. 47. — Link slot fitted to a semaphore with balanced arm.

cabin controls a coupling rod B at the end of which is a link.

Placing the arm at line clear is controlled by a coupling rod D, the bottom end of which is connected to a crank C which swivels on a pin, the carrier of which is bolted to the signal post.

The coupling rod A is joined to the end of a balance lever E, to the other end of which is attached a die which can move in the link of the coupling rod B by swivelling on its central pin *which is a fixture in the crank C.*

Let us suppose that in the first place

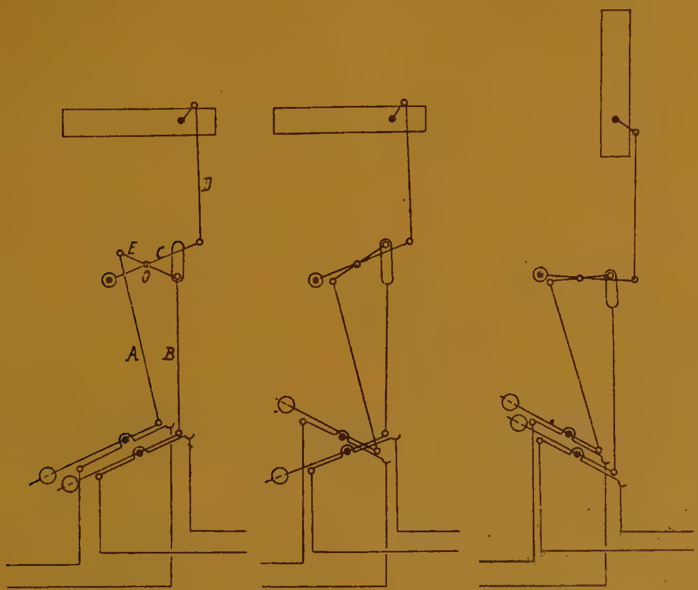

Fig. 48. Fig. 49. Fig. 50.

Figs. 48 to 50. — Diagrammatic representation of the working of the link slot.

the lever in the local cabin is worked; the lowering of the coupling rod A turns the lever E on its spindle *o*, as shown in figure 49, the die moving from the bottom to the top of the link. Crank C being controlled by the weight of the arm remains stationary, and if after this first operation the lever in the slot cabin is manipulated, the coupling rod B being pulled downwards drags with it through the medium of the die the balance lever E. The opposite extremity of the latter being held in position by the coupling rod A, the lever pivots round the centre pin *o* of this coupling rod, at the same time pulling down with it the crank C, thus causing the signal arm to be placed in the line clear position (fig. 50).

By reversing the order in which the levers are manipulated, the arm will be worked in the same way.

The slot lever that is worked first will lower the coupling rod B with its attached link without moving the signal arm, and the later manipulation of the local hand lever will turn the balance lever which swivels on its die now resting against the

top end of the lowered link, and the arm will be placed at the line clear position.

It will be seen from figure 50, that in this last position of the signal arm, the replacing of one of the two levers in its normal position would cause the arm to be brought to danger.

In order to make sure that replacing the arm to danger shall happen in the case where the slot lever is the first to be brought back to its normal position, an angle plate is fixed on the crank controlling the arm (see figure 47) against which the top part of the coupling rod B strikes when it is put back to danger, thus forcing the crank to return to its original position.

The counterweights of the balance levers working in conjunction with the disengaging balance levers are provided, not only to facilitate the fall of the arm in case one of the pull to danger wires breaks, but also to help to bring back to its original position the transmission wire of the lever last placed at danger. It should be noticed in fact that the weight of the arm favours this « pull back » effect in the wires, and this action being absent when the second lever is put back to its normal position, it is advisable to replace it by means of a balanceweight.

This point is most important, because it should be understood that on account of a wire that is wanting in tension not being pulled back far enough, serious friction may occur at the working joints of the slot arrangements by insufficient lubrication, and it might happen that one of the parts of the slot device and the corresponding disengaging balance lever might not quite return to the normal position, which would partially « arm » the slot for a later operation.

Cesar's rotary slot. — Whilst the link slot is fixed to the semaphore itself, Cesar's rotary slot may be placed on the ground or at any point in the run of the wires. The link slot necessitates fixing two double transmission wire runs up to the signal, whilst with the rotary slot it is only necessary to fix one double transmission wire run between it and the signal. It is usual to place it at the point where the wires coming from the local and the slot cabins meet, and by this means a saving is made of a double transmission wire between the slot and the signal. It is for the sake of this saving as well as for the ease of fixing and upkeep that the rotary slot is often used instead of the link slot.

The rotary slot has the advantage of being easily inspected, kept in good working order, and fixed in position, and it ensures the signal being placed at danger when either of the hand levers is replaced to its normal position and also allows the signal to automatically return to danger in case one of the transmission wires breaks.

Diagrammatic description (fig. 51). — The hand levers 1 and 2 worked by the signalmen control the action of the movable blades 3 and 4, and these in their turn work the signal arm through the medium of a swinger 7 fitted with a crossbar 10 which oscillates round a spindle 16 inserted in the pull off wire of the signal arm.

The blades are fitted with studs 9 and 9′ for the use of crossbar 10, as well as notches 17 and 18 in which swinger 7 can be partly embedded.

Operation. — When one of the levers, No. 1 for instance (fig. 52), is reversed, blade 3 is displaced and swinger 7, which is held up by stop 9′, as well as by the weight of the arm, leaves the notch 17 and swings into notch 18 of blade No. 4 so

as to allow blade 3 to pass freely along. In this way the result shown in figure 52 is obtained and the arm is placed at danger.

If now the second lever is reversed, swinger 7, which is held in notch 18 and unable to leave it, because guided by blade 3, is pulled along by the motion of blade 4, and its descent causes the arm to be placed at line clear by means of the pull exerted on the wire. In this way the result shown in figure 53 is obtained.

Placing the signal at danger is the natural consequence of putting either of the levers 1 and 2 into their normal position, thanks to the studs 9 and 9′ which carry with them the swinger in their ascent and so force the signal arm to come back to danger.

Description of the apparatus (fig. 54). — The rotary slot properly so called is only a repetition in a circular form of the arrangement just described. Its essential parts comprise two socketed discs 3 and 4 with cranks 5 and 6 which are threaded on a fixed spindle 0 and enclosed in a hollow pulley 8 carrying a balance lever 7 at the ends of which are fixed the rollers 19 and 20. The discs 3 and 4 with their notches 17 and 18 and their stops 9 and 9′ take the place of blades 3 and 4 (fig. 51) with their notches 17 and 18 and their studs 9 and 9′.

The swinger 7 (fig. 51) with its inclined planes, its spindle 16 and crossbar 10 is replaced by the balance lever 7 (fig. 54) with its rollers 19 and 20 and centre pin 16 combined with stop 10. This spindle 16 and stop 10 form part of the hollow pulley 8 which acts as gear case and takes the place of the pulley 8 in figure 51. Pulleys 5 and 6 (fig. 51) are replaced by the disengaging balance levers 1 and 2 (fig. 54) which work the socket discs 3 and 4 by means of cranks 5 and 6.

Finally, a stop 14 (fig. 54) which, coming to rest against the projection 13 of the framework *b*, fixes the exact position of pulley 8 when at danger. Another stop 12 on crank 5, as well as a similar stop 12 on crank 6, fix the exact position of the said pully for line clear when coming into contact respectively on the standards of the carrier *b* at 11 and 11′.

The levers controlling the signal are coupled up to the disengagers 1 and 2 by the ordinary wire connections, and in a similar way the disengager of the signal arm is coupled up to the pulley 8. The latter is hollow and filled with oil up to the level of its centre pin and protects in the same way as a gear case the swinger with its roller and discs which are in this way permanently lubricated. The Belgian State uses for this purpose « oleo-naphtha » B. Absence of efficient lubrication might cause seizing and binding of the spindles on the other hand adulterated oil might freeze in Winter and stop the working of the slot apparatus. It is important therefore to see that only the best oil is used, and steps should be taken to prevent any rain water entering the gear case. For this purpose the joint (in paper) must be in good condition, and the nuts of the bolts which fasten the gear case cover be well tightened.

If rain water found its way into the gear case, it would, on account of its difference in density, pass to the bottom and gradually increasing in volume would finish by expelling the oil out at the centre pin joint. A periodical examination should therefore be made of the case, and with this in view, a copper screw is fixed at the bottom of the case, which if unscrewed, the state of the liquid inside may be determined.

Fixing a balanceweight to the crank worked by the slot lever (fig. 55.) — The

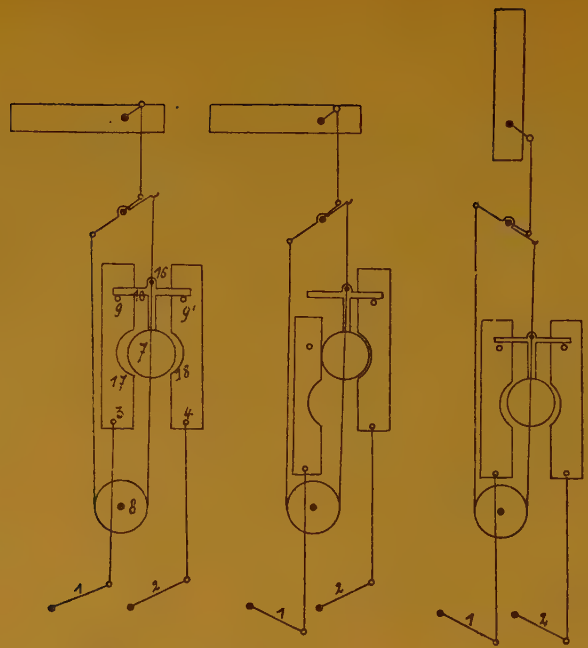

Fig. 51. Fig. 52. Fig. 53.

Fig. 51 to 53. — Diagrams showing the action of Cesar's rotary slot.

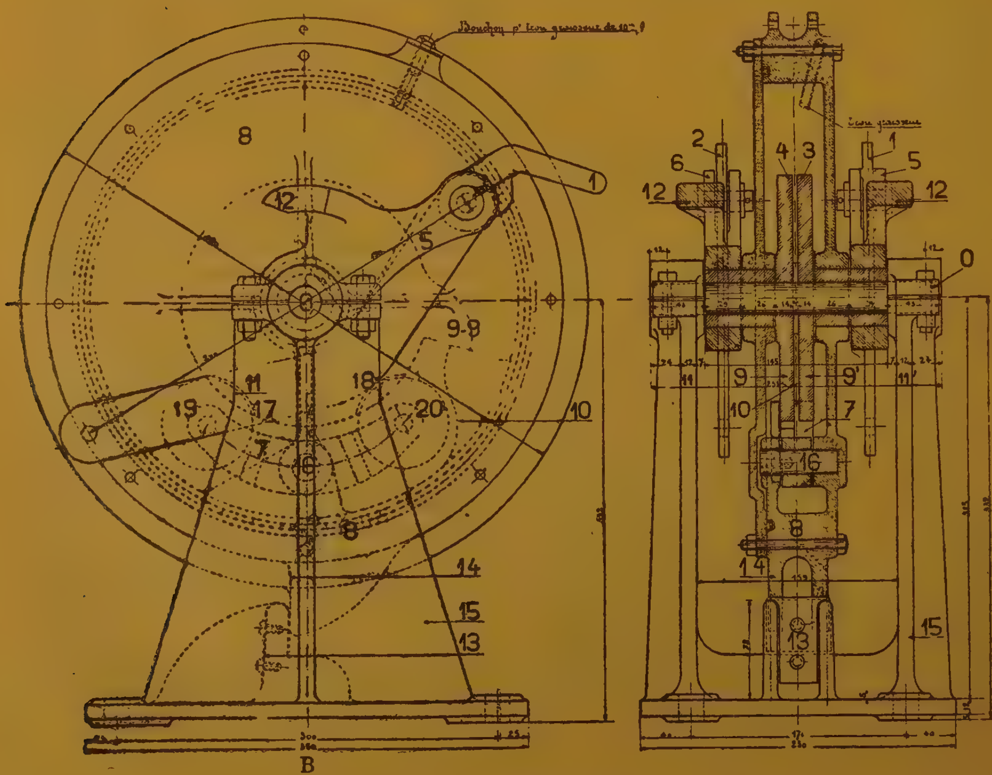

Fig. 54. — Cesar's rotary slot.

remark made on the subject of placing the levers working a link slot to danger equally applies to the rotary slot.

A signal is generally placed at danger by means of the local lever, and in this case the return to the normal position of the transmission wires controlled by this lever and consequently the corresponding crank of the rotary slot is assisted by the action of the arm falling.

On the other hand, the slot lever being operated last only serves to bring back the balance lever, crank, and corresponding disc to their original position. It may, however, happen that if the transmission wires are somewhat long and their adjustment faulty that these parts do not come back completely to their original position, which would « arm » the slot for the following operation. In order to avoid this and to assist the return of the transmission wire of the slot lever, a balance-weight is fixed in the neighbourhood of the rotary slot coupled up by means of a light chain to the crank M working in conjunction with the slot lever (see figs. 55 and 56). All that is necessary in order to couple up the chains to this

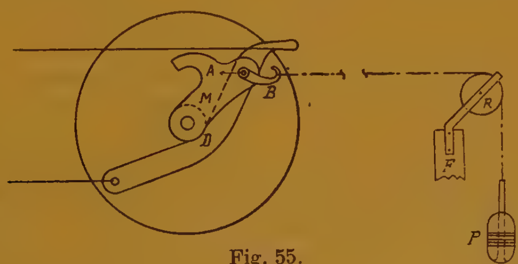

Fig. 55.

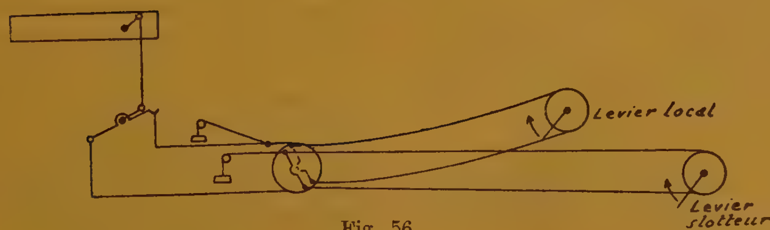

Fig. 56.

crank is to replace the existing shaft by a longer one and attach to the latter a hook B.

Adjustment of the rotary slot. — The transmission wires should be well stretched, and in normal position, the exterior stop of the gear case should come into contact with the corresponding stop of the carrying frame. In this position the two outside cranks and the two disengaging balance levers should be at the same angle. The rotary slot being reversed after operating the two levers, the arm should be absolutely in the line clear position and the two cranks should at the same time be in contact with the stops of the carrier.

Breakage of the pull to danger wire. — The rotary slot is fitted with two disengaging balance levers, so that if the pull to

danger wire breaks, either between the local cabin or the slot cabin, the corresponding disengaging balance lever should at once turn over, or at any rate at the first operation of the hand lever, if the breakage took place when the levers were in the danger position.

If the pull to danger wire breaks between the slot and the arm, the disengaging balance lever of the signal arm should act as already explained.

Experience has shown, however, that in certain cases the pull to danger wire breaks between the operating lever (local or slot) and the rotary slot, and even the disengager of the latter has swung round, the signal arm remained at line clear until the lever working the transmission wire that is still intact was put back to danger.

This happened because the balance-weight of the balanced signal arm was not sufficiently heavy to pull back the transmission system and so return the gear box to its normal position.

This fault, when found to exist, is remedied by adding a balanceweight B coupled up, by means of a chain, to the pull off wire in proximity of the slot, as shown diagrammatically in figure 56.

Multiple slotting of signal arms; use of the disengager (1). — The slotting of a particular signal from several cabins can be done by placing several rotary slots in series. An installation of this kind, however, is not to be recommended if we take into consideration the necessity of obtaining with certainty the automatic replacing the arm to danger in case of the pull to danger wire breaking in one of the runs.

It is preferable and generally cheaper to make use of the electric disengager instead of mechanical slots for the multiple slotting of signals.

The disengager or replacer is a well known electrical contrivance which is not only used as a slot, but serves also to automatically replace certain block signals to danger.

It is fixed on the signal post itself, and only requires, in addition to the electric circuit, one double wire transmission, *viz.*, that coming from the local cabin. It works, by means of an external balance lever, a pulling device situated inside the protecting case. This pulling device can communicate its action to a second internal device which is connected to the signal arm by means of an outside crank. The pulling forward of this second device is obtained by means of an electro-mechanical coupling which includes an electro magnet. The coupling up can only take place when the electro magnet is excited and its armature attracted.

The electro magnet of the replacer is inserted in a battery circuit passing by the slot cabins where the switches are fixed. One replacer can therefore in this way serve for slotting a particular signal arm from a number of cabins. The arm being placed at line clear falls automatically to danger if the electric circuit is broken at any point, or if the circuit, remaining unbroken, the lever in the local cabin is replaced at danger.

Slotting of distant signals. — When a home signal is electrically slotted by means of a disengager, its distant signal should also be electrically slotted by means of a disengager inserted in the same electrical circuit as the former.

When the home signal is slotted by means of a rotary slot, its distant signal can be slotted with a second rotary slot *operated by the same lever as the first,*

(1) With certain somewhat similar arrangements in Great Britain this is called a « replacer ».

but it is preferable to slot the distant signal by means of a disengager inserted in an electrical circuit containing a switch worked by the home signal arm.

It shoud be mentioned that in order to ensure perfect agreement between the position of the distant and that of the home signals, an electric bell rings in the cabin when the home signal shows line clear and the distant signal it at danger. When the distant signal is slotted, as in the case of the home signal, the bell rings each time there is not perfect agreement between the two signals.

Stops used in Cesar's slot system. — Working signals that are electrically slotted by means of disengagers can only be carried out in proper order. The slot cabin is obliged to work its switch in order to excite the electro magnet of the disengager and allow the throwing into gear that must occur in order to place the signal at line clear.

The use of mechanical slots, to the contrary, makes it possible to change at will the order of working, the arm being placed at line clear under the action of the second lever worked. It is often desirable, however, that the slot cabin should be the first to operate its lever, for if it were otherwise, it is the slot lever, generally fixed some distance away, which has to support all the effort required to place the signal at line clear, and under these conditions the working of it becomes so hard that the arm occasionally remains in an intermediate position for line clear, instead of coming right over into its proper place. This situation is made still worse when the same slot lever works two slots at once.

A solution to this inconvenience was adopted in the old Saxby installations, which consisted in working from the slot cabin, at the same time as the slot itself, a sheet iron plate in the form of a disc, and an alarm bell, both of which were placed in the local cabin. The reversing of the disc and the tinkling of the bell warned the signalman that the slot cabin had operated its lever, and the local instructions were that the local lever was not to be worked until this alarm had been received.

These sight and sound indicators were generally difficult to adjust and unreliable in action, and besides did not prevent working the signals out of their prescribed order.

The apparatus shown in figure 57 and called the « slot stop » has taken the place of the above and makes it obligatory to work the levers in their proper sequence.

Its essential point lies in the arrangement of two bars A and B inserted respectively in the pull off wire of the slot cabin and of that of the local cabin.

The first bar is shaped on the top so as to form an inclined plane, and the second bar is cut to form a toothed rack. A pawl C, which turns freely round a spindle D, catches in the rack and thus prevents any displacement of the bar B, and consequently any working of the lever in the local cabin.

This is only possible after operating the slot lever, the result of which is to move the bar A towards the left. This displacement forces the pawl C to rise progressively under the action of the inclined plane until it is high enough to liberate the rack and so allow the signal to be worked from the local lever. An electric contact made through the means of a blade E which forms part of the pawl is inserted in the circuit of a visible electrical indicator placed in the local signal box so as to warn the signalman that the signal is « unslotted ». By this means the signalman in the local box is prevent-

ed from attempting to work the signal lever before he should do.

This sight indicator works in conjunction with a bell arrangement which tinkles from the time of unslotting until the local lever is reversed. By this means the slot cabin cannot keep the signal unslotted after it has been put to danger without advising the local cabin. The latter will eventually take steps in order to stop the bell tinkling and request that the slot lever be replaced in its normal position.

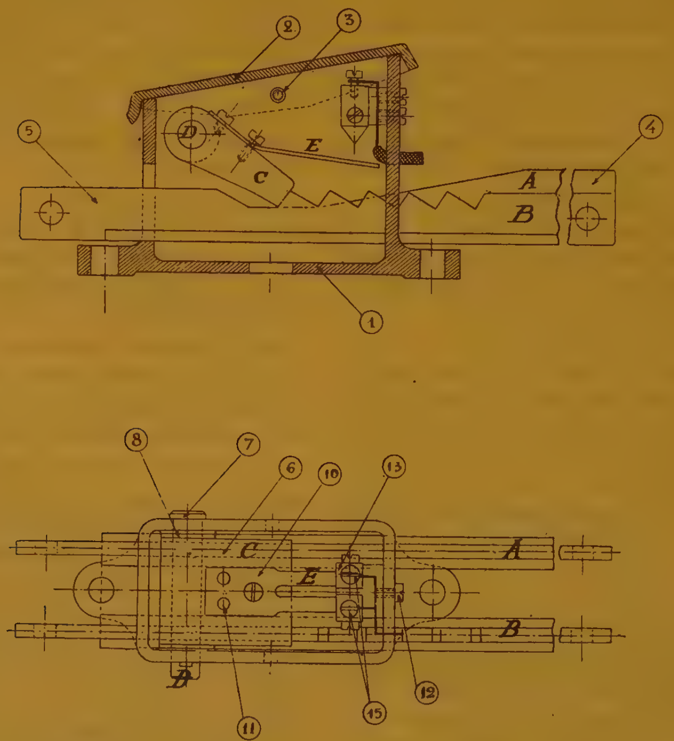

Fig. 57. — Cesar's slot stop arrangement.

When used with the rotary slot, this « slot stop » is fixed near the latter, and when coupled up with the link slot at the point where the two sets of transmission wires meet.

Operating three position signals 0 to 45° and 90°.

If we refer to the account of the new system of signalling (1), we shall see that signal arms that may be placed in three positions are of four kinds :

1° The home signal for an absolute stop, but serving at the same time as distant signal for the next home signal, and is represented diagrammatically as shown by figure 58;

(1) See the article by Mr. J. Verdeyen, published in the May 1923 number of the *Bulletin*.

2° Distant signal which repeats the indications given on a junction bracket (fig. 59);

3° A distant signal which repeats the indications of two home signals succeeding one another at a distance less than 800 m. (875 yards) (fig. 60);

4° Distant signal shown in figure 61 and which repeats not only the indications of a junction bracket, but also those of a home signal preceding it at a distance less than 800 m. (875 yards).

Fig. 58. Fig. 59. Fig. 60. Fig. 61.

The conditions for operating the signals, as mentioned in the third and fourth cases, are identical with those in the first case, but are totally different from those in the second case. It will therefore be only necessary to compare the conditions for operating in the first and second cases.

First case. — *Three-position home signal.* — The arm is under the control of two signal cabins (which is the most usual case) or at least two different levers if it is operated from one cabin.

We will first consider the arm being controlled from two cabins, the first of which we will call *local cabin* A, which can put the arm to the line clear position of 45° without interference from the other cabin, which we may call *distant cabin* B, the duty of which consists in putting the arm to 90° after it has already been placed at 45° by the local cabin and when the following signal is giving line clear.

The working of the signals has to conform to the following conditions :

1° By working the lever in cabin A when the lever in cabin B is at danger, the arm is raised to 45°;

2° By working the lever in cabin B after the lever in cabin A has been worked, the arm passes from the position of 45° to that of 90°;

3° In working the lever in cabin B before the lever in cabin A has been worked, the arm remains in its position;

4° In working the lever of cabin A after the lever of cabin B has been worked, the arm passes directly to the vertical position.

Further, *the arm being vertical* :

5° If the lever in cabin A is brought to its normal position before that of cabin B, the arm immediately falls from the vertical position to the horizontal one;

6° If the lever of cabin B is brought to the normal position before the lever in cabin A, the arm falls from the 90° position to that of 45°;

Finally :

7° If the lever in cabin A is brought to its normal position after the lever in cabin B has already been brought to its normal position, the arm passes from the 45° position to the horizontal one.

Second case. — *Three-position distant signal repeating the indications of a junction bracket.* — The arm in this case is worked by two levers in the same cabin (that controlling the arms of the junction bracket).

The controlling levers, distinguished by letters A and B, are interlocked, and we will suppose that lever A works the arm

protecting the branch line, and lever B that of the main line. The method of working is as follows :

1° Lever A being worked, the arm passes from the horizontal to the 45° position;

2° Lever B being worked, the arm passes from the horizontal to the vertical position.

Note that A and B cannot be worked simultaneously and that the arm cannot pass from the 45° position to that of 90°, nor inversely from that of 90° to 45°.

The conditions to be conformed to for working are therefore much simpler than those we examined in the preceding case.

The conditions to be conformed to when working in the *first case* are obtained by the use of *Cesar's slot arrangement for three-position signals* or by *the slot of the type made by the « Ateliers de Construction électriques de Charleroi »*. The conditions for operating in the second case are obtained by the use of a *balance lever with unequal arms.*

Cesar's rotary slot system for working three-position signals. — Figures 62, 63, 64 and 65 shown diagrammatically the different phases when working. The principles on which the construction of this apparatus are based are the same as those which governed the construction of the ordinary rotary slot, the only alteration being in a simple method for liberating the blades.

Figure 62 shows the apparatus in its normal position, the two controlling levers being at danger. Swinger 7 is engaged in notch 17 of blade 3 and cannot get out as it is held in that position by blade 4; it is therefore obliged to follow blade 3 when this descends under the action of *lever 1 in the local cabin.* Blade 3, however, does not carry swinger 7 with it the full length of its displacement, for whilst notch 17 decends from the plane marked by the horizontal line AA down to the plane marked by the horizontal line CC, the swinger stops in notch 18 in blade 4 which is controlled by lever 2 in the distant cabin. The swinger is obliged to remain in this notch (see fig. 64) because its balance lever 10 is stopped by the stud 9′ in blade 4. Now the swinger in passing from plane AA to plane BB has drawn with it the arm which has risen from the horizontal position to that of 45° (fig. 64) and the blade 3 has continued on an over-travel, the amplitude of which is measured by the distance separating plane BB from plane CC. It is, thanks to this over-travel, that the 45° position is accurately obtained and made independent of the uncertain variations in the transmission wires from local lever 1.

Lever 1 having been worked and the arm occupying the 45° position, if lever 2 in the remote cabin is now worked, swinger 7 which is held in notch 18 of blade 4 will follow the descent of the latter in which its notch passes from plane BB to plane DD. The swinger, however, will be stopped in the middle of this travel by the stud 9 in blade 3, and at the same instant when the swinger finds itself opposite notch 17, it will have travelled from the plane BB to plane CC, thus bringing the arm from the 45° position to the vertical one. Blade 4 will have continued in making an over-travel measured by the distance separating plane CC from plane DD (fig. 65).

We should point out that in order to bring the arm into the exact vertical position depends, in any case, on the position of the blade 3 worked by the lever in the local cabin. This is an advantage, because as a rule the transmission wires

of this lever are generally fairly short, and for this reason can be more easily adjusted. If as shown in figure 63 remote lever 2 had been worked before local lever 1, blade 4 would have descended (its notch passing from plane BB to plane DD) without the swinger being brought along by this action, and supposing this has happened, the arm will remain at danger, but if lever 1 is worked after lever 2, the swinger 7 will be carried forward by blade 3 during the whole travel of the latter, and the swinger will pass directly on from plane AA to plane CC (fig. 65) bringing with it the arm which will rise vertically.

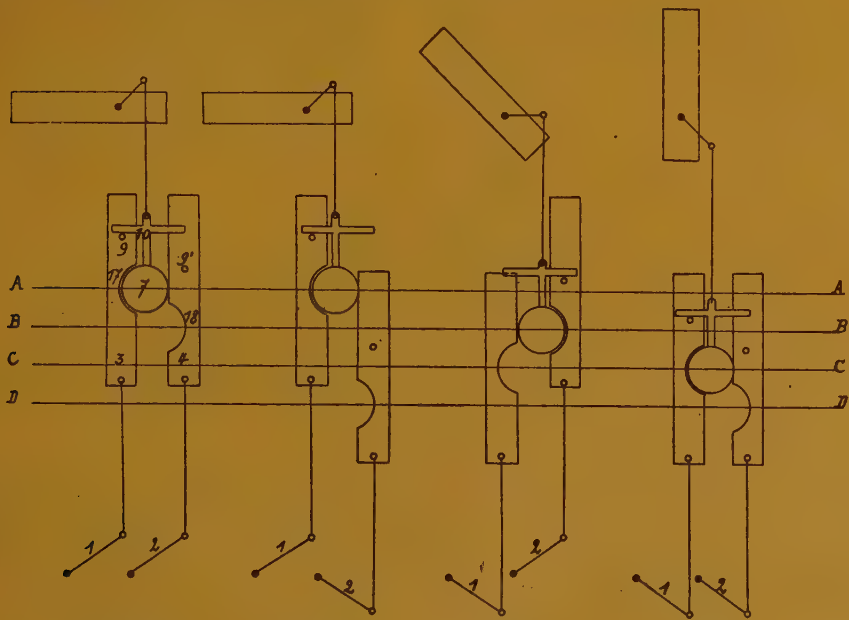

Fig. 62. Fig. 63. Fig. 64. Fig. 65.

Figs. 62 to 65. — Diagrams of the working of Cesar's rotary slot system for three-position signals.

The arm being now in the vertical position, if lever 1 is put back into its normal position, blade 3 will pull the swinger up by means of the stud 9 during the whole length of its travel and the swinger will thus pass from plane CC to plane AA directly, bringing with it the arm from the vertical to the horizontal position.

If lever 2 of the distant cabin is put into its normal position before lever 1, the signal being vertical, blade 4 in ascending will catch, at its half travel, the swinger 7 through the medium of its balance lever and the stud 9′, and pull it along during the remainder of its course so that the swinger will pass from plane CC to plane BB, bringing the arm from the vertical position to that of 45°.

Finally, the arm being in this position of 45°, if the local lever 1 is put back to danger, it is plain that blade 3, by means of stud 9, will catch the balance lever of the swinger. The latter will enter notch 17 leaving at the same time notch 18, and

will accompany blade 3 for the rest of the travel passing from plane BB to plane AA and acting on the arm so that it returns to the horizontal position.

All the requisite conditions enumerated above have therefore been complied with.

Construction of Cesar's rotary slot for working three-position signals. — Though the essential points of the ordinary rotary slot have been adhered to in the arrangement of the slot for three-position signals, the construction, however, of the latter differs entirely from the first type.

The slot for three-position signals is fixed to the shaft which rotates the arm. The swinger 7 in figure 62 is replaced by crank 7 (fig. 66) which is strongly keyed to the signal arm shaft. This crank is jointed to a balance lever fitted with two loose rollers. The outside cranks 1 and 2 (corresponding to levers 1 and 2 in figure 62) are cast in one piece (cast steel) with their respective dished bosses 3 and 4 (corresponding to blades 3 and 4 in figure 62).

The recesses in these bosses encircle the upper part of the crank keyed to the shaft, and in its normal position the latter comes into contact with a projecting part of the boss 3 joined up to the local lever; this projecting part is shown in dotted lines behind the balance lever 7 in the cross section, and is indicated by the figure 9 in the view in elevation and corresponds to stop 9 in figure 62. The stop 9′ in boss 4 is also obtained by means of a projection from the latter and is shown dotted in both views in figure 66; the crank coming into contact with this stop in course of its rotation.

The signal being at danger in its normal position, one of the balance lever rollers is lying in the notch 17 of the boss 3 which is joined up with the local lever. The balance lever is thus held stationary, the other roller being at this moment in contact with the periphery of boss 4.

When the local lever is worked, crank 1 is drawn downwards and travels 200 mm. (7 7/8 inches) measured on the vertical passing through the centre of the hole through which the shaft passes at the free end of the crank. In accomplishing this movement, the crank turns the boss clock-wise through an angle of 90°, and by means of notch 17 and the corresponding roller, the boss pulls crank 7 round, which being keyed to the shaft of the signal arm, pulls round in its turn this shaft, and the signal itself in its rotary path. Crank 7, however, is stopped at the middle of the travel of the boss by stop 9′ belonging to boss 4, and at the time crank 7 meets this stop, the second roller of the balance lever enters notch 18 and this allows the second roller to disengage itself from notch 17.

Crank 7, the shaft of the arm, and the arm itself will have only turned through 45°, while crank 1 and boss 3 will turn through 90°, thus making an over-travel of 45°.

The arm being raised to 45°, if the distant lever is worked, crank 2 will turn the boss 4, and as this at the time forms one with crank 7 and the signal arm shaft through the medium of notch 18 and its corresponding roller, the arm is pulled round in the travel of boss 4, the latter turning through an angle of 90°. As in the preceding phase, however, the crank and the arm will only move through the first half of this travel, because at the end of the half distance, crank 7 will come into contact with stop 9 of the boss, whilst the right hand roller of the balance lever will enter notch 17 of this boss, thus allowing the second roller to

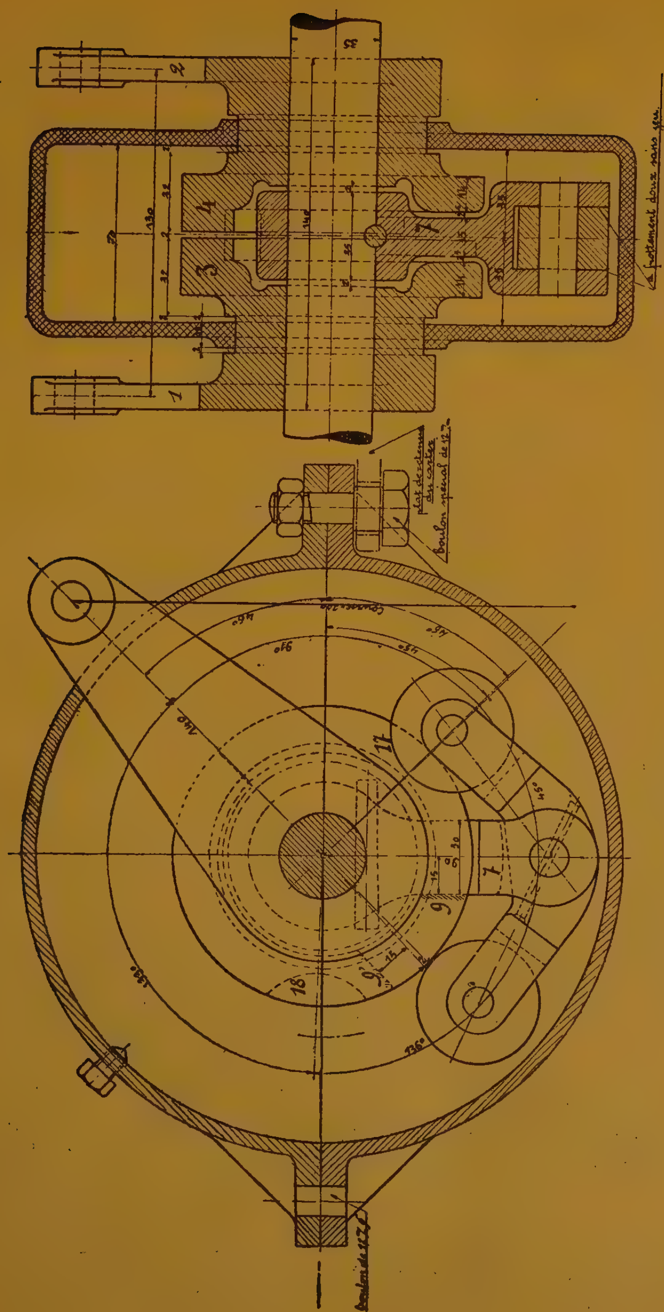

Fig. 66. - Cesar's rotary slot for operating three-position signals.

leave notch 18 and boss 4 to accomplish its over-travel corresponding to an angle of 45°.

Placing the local lever 1 into its normal position before lever 2 causes the signal arm to be brought to danger by means of the continuous action of the stop 9 on the crank; and placing lever 2 in its normal position before lever 1 brings the arm to 45° by the action of stop 9′ on the crank.

The bosses, crank 7 and the rollers are enclosed in a cast iron gear case in two parts, which are bolted together with a paper joint inserted between the flanges. This gear case is half filled with oil to avoid the seizing of the rollers and spindles, « oleo-naphtha B » being used for this lubrication by the Belgian State.

Zinc covering. — It is of the utmost importance to prevent any rain water entering the gear case, for if this should happen through any defective joint, the water would sink to the bottom of the casing and gradually expel the oil which would leak away at the shaft joint, and the freezing of this water in Winter would prevent the working of the signal.

In order to completely avoid any filtering in, the slot apparatus for three-position signals is covered with a zinc casing fixed on to the gear case itself below the joint by means of the bolts connecting the parts of the case together, in this way any entrance of rain water is practically impossible.

As an additional precaution, a copper screw for emptying purposes is fitted in the bottom of the gear case, thus allowing a periodic examination to be made of its contents.

Recommendations. — The keying of the crank on to its shaft should be most carefully done in order to avoid any risk of it becoming loose, and the pins of the balance lever (centre and roller pins) being in constant use should be made in case hardened steel. These should be examined periodically and renewed if any signs of wear or seizing are noticed.

The spindle joining up cranks 1 and 2 to the operating coupling rods should be solidly cottered up by means of a double cotter fixed at its end, and it is worth while drawing attention to this detail, because it is easy to see that any accidental uncoupling of the operating rod worked from the distant box, or uncoupling resulting from the dropping of the spindle, would cause crank 2 to fall downwards in consequence of its own weight, this crank having in fact nothing else to turn but boss 4. The consequence of any irregular rotation of this boss would be to bring the arm to 90° if the local lever only is worked.

Note. — The travel of crank 1 worked from the local cabin cannot be altered in any case, because by its means the position of the signal at 90° is maintained; this, however, does not apply to crank 2 corresponding with the distant lever. This crank has a travel of 200 mm. (7 7/8 inches) measured vertically from the centre of the hole in which the shaft works.

The disengaging balance lever also travels 200 mm. measured vertically from the centre of the hole for the spindle situated at the end of the balanceweight lever.

We may point out that in these conditions the passing of the arm from the 45° position to that of 90° takes place during the first half of the travel of the disengaging balance lever, that is to say, during the travel of the first 100 mm. (3 7/8 inches) of this lever. Now, anything out of order in the transmission system of

the distant lever may cause the disengaging balance lever to fail to come to the end of its travel. Let us suppose that in consequence of some abnormal fault in the pull to danger wire a loss of travel is produced in the return of the balance lever and that this has remained raised to a height corresponding to a loss in travel of say 50 mm. (1 7/8 inches); in consequence of this loss in travel boss 4 will not have returned to its original position, but will be as much as 22° 30′ out of it, which in case of working the local lever would bring the signal arm to 67° 30′, instead of 45°.

Let us now suppose that the over-travel of boss 4 was entirely done away with, and only a travel of 100 mm. (3 7/8 inches) was given to crank 2 instead of 200 (7 7/8 inches) (which could be obtained by halving the arm of the counterweighted balance lever coupled to the disengaging balance lever) the loss of 50 mm. (1 7/8 inches) travel, as previously taken into account, would be reduced by half, because of the corresponding reduction of the arm of the crank lever, and boss 4 will only be displaced by an angle of 11° 15′ instead of 22° 30′, which would be less dangerous from a safety point of view.

This method of doing away with over-travel, which we have just explained in order to make things clear, cannot, however, be put to practical use, because the run of the wires to the distant cabin are generally of some length, and the absence of over-travel would cause the arm to be placed in doubtful positions.

The true solution consists in reducing the total travel and keeping at the same time sufficient over-travel. We may adopt for instance a total travel of 150 mm. (5 7/8 inches) instead of 200 mm. (7 7/8 inches). which may easily be obtained by putting the coupling joint of the acting coupling rod further back towards the centre of rotation of the counterweighted balance lever.

Fitting up the slot for three-position signals.— Adjustment.— Figure 67 shows the apparatus fixed on a semaphore. The triple spectacle frame is fitted with red, yellow and green roundels, starting from the top to the bottom.

The disengaging balance levers are fixed on each side of the post, and each of the balance levers, coupled up to the disengaging lever, is fitted with a balanceweight for the purpose of ensuring that the working parts of the slot apparatus shall return to their normal position in case a pull to danger wire breaks, and also to assist the « pull back » of the transmission wire when the hand levers are put back in their normal position.

The arm being at danger, the boss worked from the local lever is bearing against the roller balance lever crank, which rigidly following the position of the signal arm, is at this moment vertical.

The angular normal position of crank 1 (worked from the local lever) is therefore automatically determined, and the length of the coupling rod working the signal from this crank is measured by placing the disengaging balance lever at the end of its travel, whilst the signal arm is horizontally fixed against its stop, and the boss worked from the local lever is in contact with the crank of the roller balance lever (fig, 66).

All that is necessary to fix the length of the second coupling rod, *the signal arm being horizontal, is to place the second crank of the slot at the same angle as the first crank,* for in this position the centres of the holes for the pins of these two cranks should be exactly at the same level.

The crank worked from the local lever

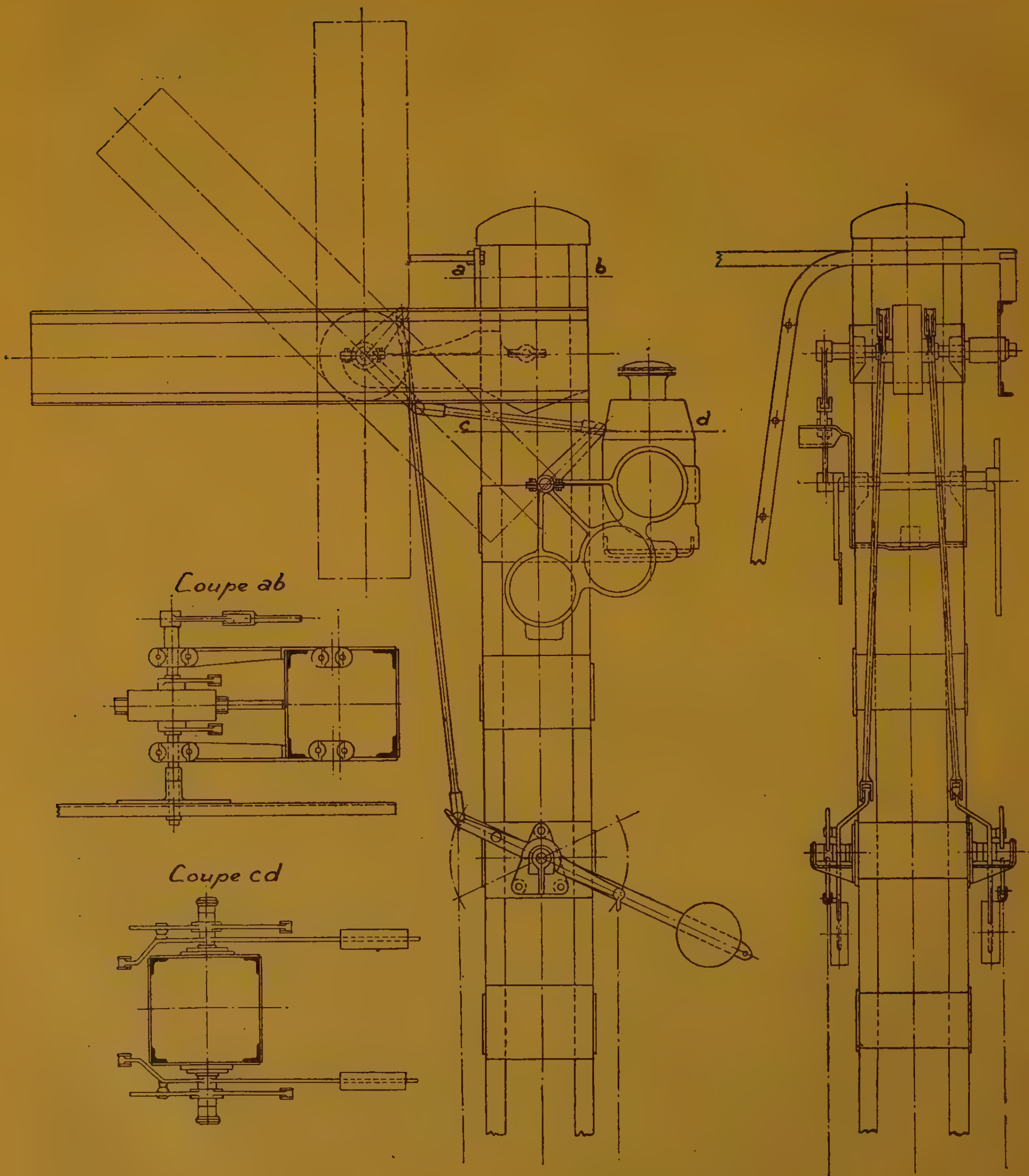

Fig. 67. — Three-position home signal worked
by means of Cesar's rotary slot fixed behind the arm on its rotating spindle.

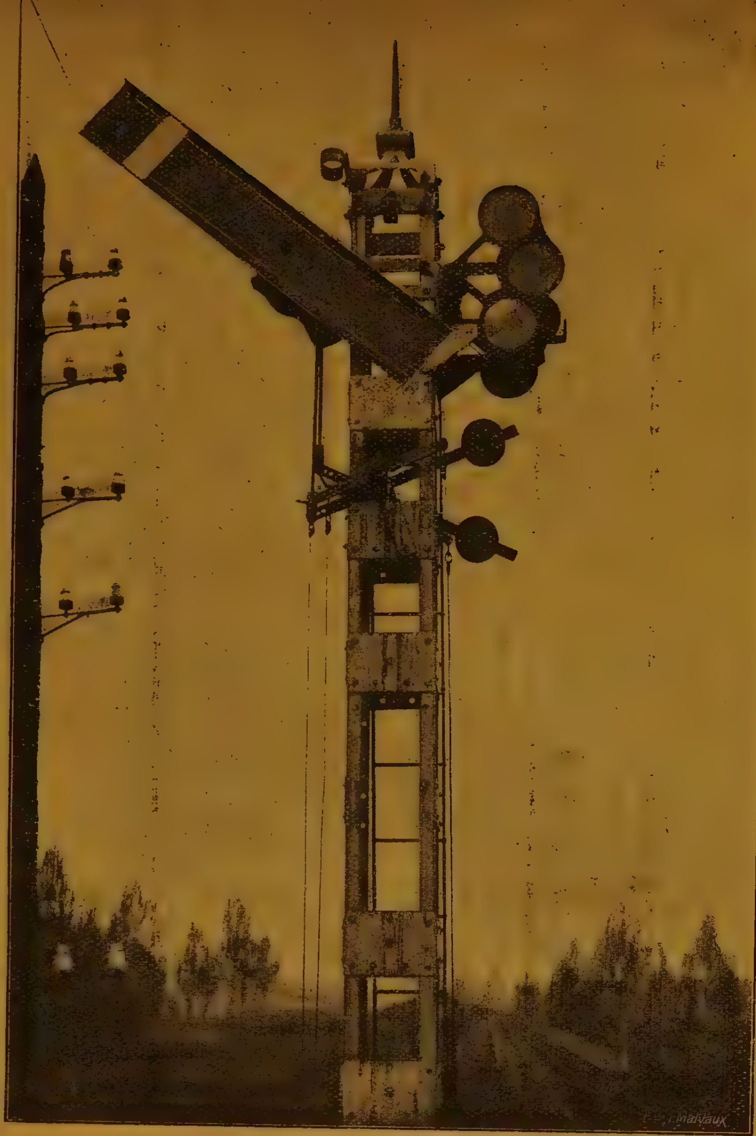

Fig. 67*bis*. — Three-position signal arm worked by means of a Cesar's rotary slot. (45° position.)

Fig. 67*ter*. — Three-position signal arm worked by means of a Cesar's rotary slot. (90° position.)

should travel through an angle of exactly 90°, this travel being fixed in both directions by means of the horizontal and vertical stops of the signal arm.

It should be noted that the travel of the second crank, worked from the distant lever, is only limited by the length of the coupling rod working it, and indirectly by the stops formed by the carrier of the disengaging balance lever.

We have just seen, however, that this travel, though normally 200 mm. (7 7/8 inches), is often reduced to 150 mm. (5 7/8 inches) so as to minimise the effect of the transmission system if it gets out of order.

Under these conditions, the parallelism of the cranks only exists in their normal position, and it is wise to make certain that the crank worked from the distant cabin cannot even under the influence of a sharp pull go to any appreciable extent further than its proper amount of travel (towards the bottom). We think this ought to be pointed out, because there is no stop to fix the limit of this travel, and one might be afraid of the crank getting into a straight line with the coupling rod working the arm and becoming wedged which would prevent it operating.

The length of the coupling rod should be adjusted in consequence, and the counterweighted balance lever stops on its carrier should be checked.

The length of the coupling rod working the screens and that of the crank controlling the screens are adjusted so that the triple spectacle frame turns through an angle of 90° during the complete travel of the arm, the red glass in the spectacle frame coming before the light of the lamps when the signal arm is at danger, and the Isly blue glass will come completely before the corresponding opening of the lamp when the arm is vertical.

In order to prevent the triple spectacle frame being reversed due to a sharp pull of the hand lever, a stop limiting its travel is placed at the line clear position.

The two transmission wires should be well stretched, and any shortening of the travel should be made at the foot of the signal by means of a travel reducing balance lever.

The working of the disengaging balance levers should be carefully examined, and it should be made certain that the counterweighted balance levers come properly to the bottom of their travel in both their positions *in whatever way the lever may be worked.* This test should especially be made for the transmission wires leading to the distant lever when the latter has been put back to danger after the local lever. Similar tests should be made a few days after the signal has been put to work, choosing if possible a time when the temperature is fairly high.

Three-position signal slot made by the « Ateliers de Constructions électriques de Charleroi » (figs. 68 to 72). — The Administration of the Belgian State Railways has put into service a certain number of home signals, the arms of which are controlled by the slot constructed by the « Société des Ateliers de Constructions électriques de Charleroi ».

This slot, which has also given good results, is placed at about a man's height on the signal post in order to facilitate the examination, etc., of the interior parts,

It is made (figs. 68 and 69) of a cast iron box with a bolted cover and an india-rubber joint placed between the cover and the box. This latter has two mild steel spindles 3 and 4 passing through it and fixed in the same straight line, one at the end of the other.

A counterweighted balance lever 1 coupled to a disengaging balance lever is keyed on to spindle 3 in front of the box, whilst behind the latter a second counterweighted balance lever 2, also coupled to a disengaging lever, is keyed on to spindle 4.

The action of the disengaging levers 1 and 2 is therefore to turn respectively spindles 3 and 4.

Spindle 3 communicates its rotary motion to a cast steel sector 5, which in its normal position comes into contact with a roller fixed on spindle 9 of the balance lever 10. This latter is keyed to spindle 11 which passes through the cast iron box, and on this spindle is keyed outside the box, crank 12 coupled to rod 13 which works the signal arm.

A spindle 16 joins sector 5 to a balance lever 15 which is free to turn round spindle 16, and to balance lever 15 is fitted a second spindle 17, the roller of which comes normally into contact with sector 18. The latter being keyed to spindle 4 receives through the medium of this spindle the rotary motion communicated to it by the second balanceweight lever 2, as mentioned above.

In their normal position, sectors 5 and 18 come respectively into contact with the interior stops 20 and 19; the rotary motions communicated to sectors 5 and 18 are in opposite directions, sector 18 turning clockwise, and sector 5 the other way about.

Working of the apparatus.

0° to 45° position. — When cabin A (local) reverses its hand lever it pulls down the disengaging lever 1 and its corresponding balanceweight, and sector 5 takes the position shown in figure 70. The roller spindle 9 pushed back by the inclined plane *ab* of sector 5 causes the balance lever 10 to turn, and this by means of spindle 11 pulls the crank 12 and with it rod 13 which places the arm in the 45° position.

It should be noticed that the shape of sector 5 causes an over-travel to occur both before and after the working of the arm, thus forcing the latter to occupy strictly definitive positions. In fact, balance lever 10 only begins to move when its roller 9 comes into contact with the inclined plane *ab* of sector 5. On each side of this inclined plane the contours of the sector are part of the circumference of a circle having for centre the centre of the spindle 3-4, and the sliding of the roller over these contours consequently does not cause any displacement of the balance lever 10.

During the working of the arm, the roller fixed on spindle 14 of balance lever 10 remains in contact with the upper portion of sector 5, and at the instant the arm reaches the 45° position, this roller comes to rest on the top part of sector 18. When the signal arm passes from 45° to 90°, the roller 14 will only leave sector 18 so as to come to rest on sector 5, so that in this way the rollers placed on spindles 9 and 14, at the extremities of balance lever 10, always coming into contact with the sectors, it is impossible to work by hand from the outside crank 12 or the rod 13, and consequently the signal arm. The positions of these are therefore entirely due to the motion communicated to sectors 5 and 18.

45° to 90° position. — The signal arm being at 45° (fig. 70), if the lever in cabin B (slotter) is worked, the disengaging balance lever 2 and the corresponding counterweight lever are reversed, as shown in figure 71, pulling along sector 18. The rotation of the latter has the effect of bringing the arm from the

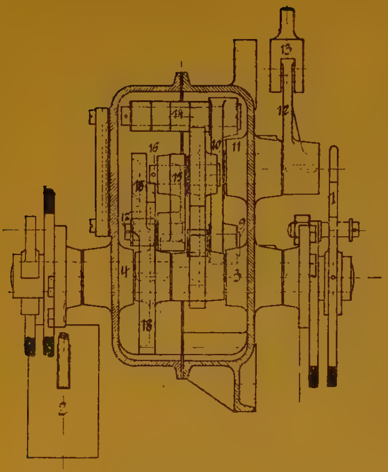

Fig. 68.

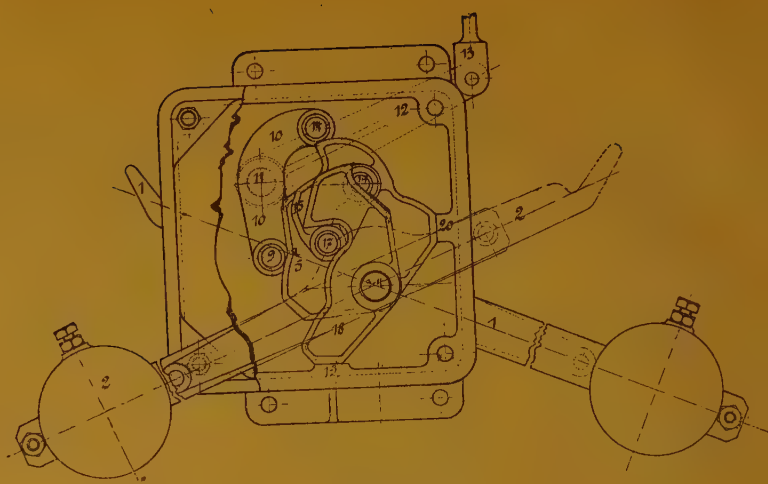

Fig. 69.

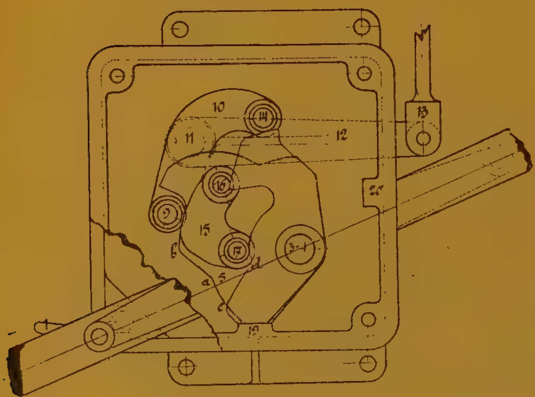

Fig. 70.

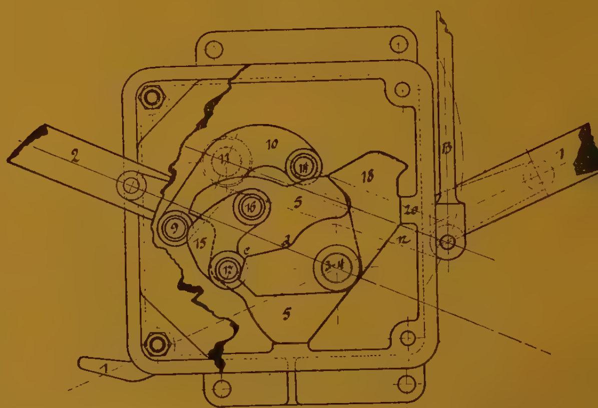

Fig. 71.

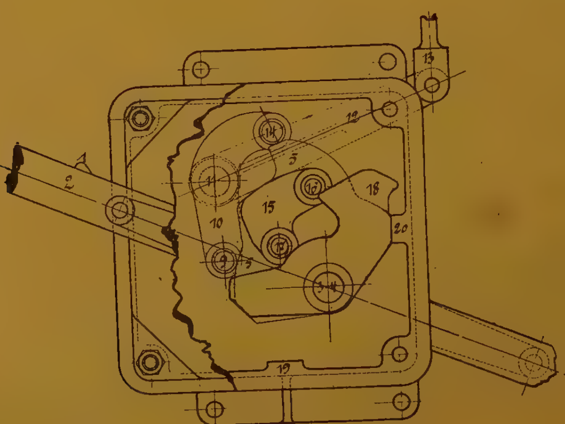

Fig. 72.

Figs. 68 to 72. — Slot for working three-position signals supplied by the « Ateliers de Constructions électriques de Charleroi ».

Fig. 72*bis*.

Fig. 72*ter*.

Three-position signal arm worked by means of a slot supplied by the « Ateliers de Constructions électriques de Charleroi ».

45° position. 90° position

45° position to that of 90° for the following reason :

After working balance lever 1 and the corresponding sector 5 (fig. 70), the balance lever 15, suspended by means of spindle 16 to sector 5, has placed itself in contact with roller 9 fixed on the spindle of balance lever 10, the roller fixed on spindle 17 of the balance lever 15 remaining in contact with sector 18.

The latter being reversed (and spindle 16 remaining stationary) pushes back roller 9, thus working balance lever 10 and consequently crank 12 as well as the arm which therefore passes from the 45° position to that of 90°.

The displacing of roller 17, and consequently its balance lever 15, is brought about by sliding on the inclined plane *cd* of sector 18, and it will be seen that on each side of the inclined plane *cd* the contours of the sector 18 take the form of a part of the circumference of a circle, having for centre the centre of spindle 3-4, so that the sliding of the roller 17 on these contours does not bring about any displacement of balance lever 15, and consequently there is an over-travel of balance lever 2 and the sector 18 at the beginning as well as at the end of the operation, thus ensuring a perfectly definite position of the arm at 45° and 90°.

Figure 72 shows the position of the parts when the arm is showing line clear, the local cabin A puts its lever back to danger before the slot cabin B, or else the arm being at danger the slot cabin has worked its lever before the local cabin.

If the local cabin A puts back its lever to the normal position, the signal being at line clear, then sector 5 in bringing back the balance lever 15 and acting on roller 14 pulls back balance lever 10 into its normal position, thus bringing the arm from 90° to 0°. In this position, however, it will be seen that on again reversing sector 5, the arm will pass directly from 0° to 90° by the successive action of sector 5 and the balance lever 15 on the roller 9.

All the requisite conditions have thus been conformed to.

The method of adjusting the transmission wires is identically the same as for Cesar's rotary slot.

Operating a three-position distant signal by means of a balance lever with unequal arms (fig. 73). — We have already examined the method of working a distant signal arm repeating the indications of a junction bracket, and it will be remembered that working one of the levers has the effect of placing the signal arm to 45°, and that working the other lever will put this arm into the vertical position; also that two levers worked from the same cabin are so interlocked that the possibility of passing the arm from 45° to 90° and *vice versa* is not feasible.

Each of the disengaging balance levers is joined up to the extremities of a balance lever, one arm of which is twice the length of the other. This balance lever is coupled up by means of its pivot, on the one hand to the end of a crank, the axis of rotation of which is fixed to a carrier bolted to the signal post, and on the other hand to the signal arm by means of a vertical coupling rod, a bell crank, a horizontal coupling rod, and a crank keyed on to the rotating shaft of the signal arm.

The counterweighted balance lever which controls the 45° position is joined up by means of a coupling rod to the end of the *long arm* of the balance lever, and the counterweighted balance lever controlling the 90° position is joined up by

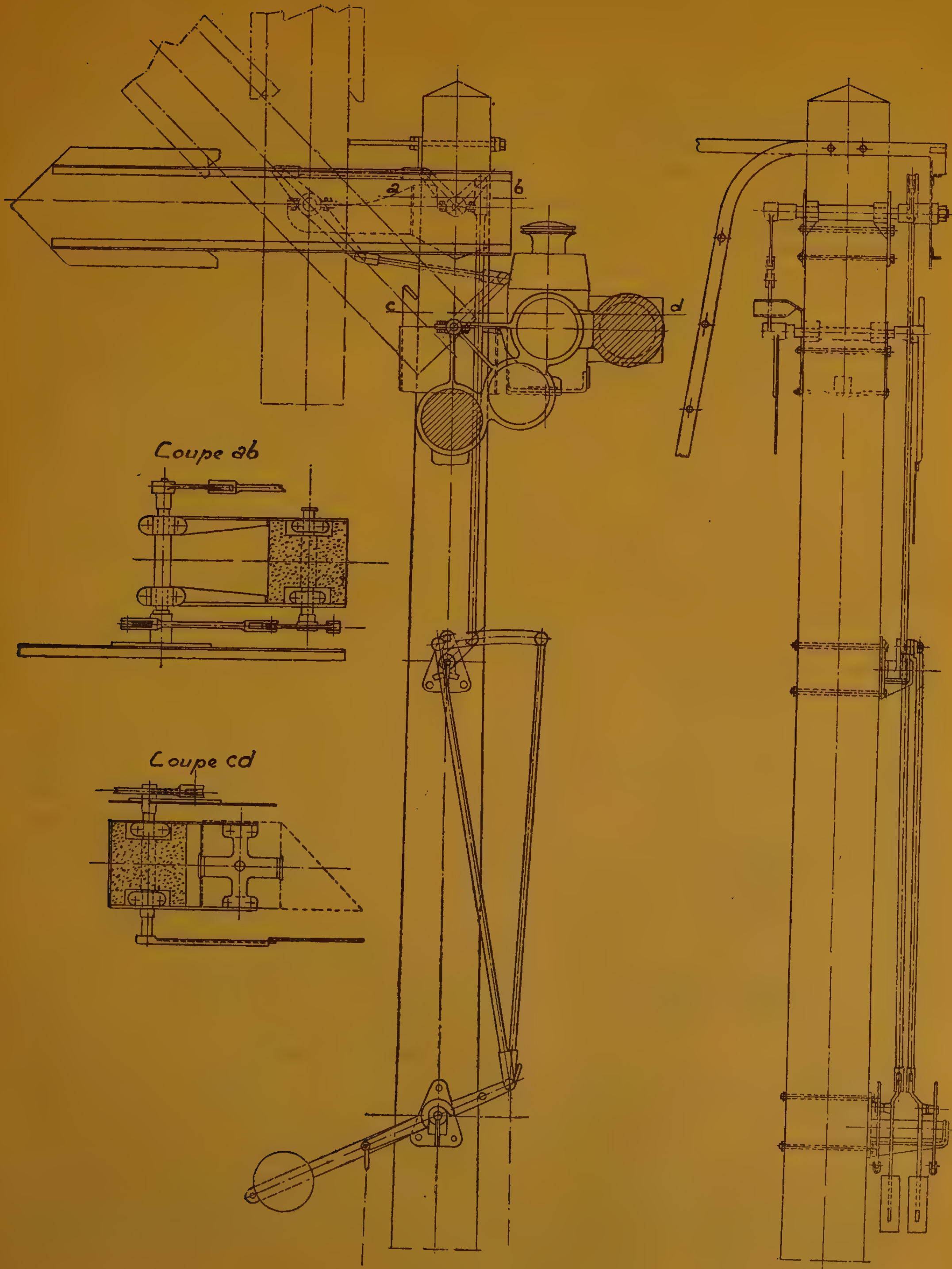

Fig. 73. — Three-position distant signal
fixed on a reinforced concrete post and worked by means of a balance lever with unequal arms.

means of a coupling rod to the end of the *short arm* of the balance lever.

The effect of working one of the disengaging balance levers naturally causes the corresponding lower extremity of the balance lever with unequal arms to be drawn down, and this action is communicated to the crank and consequently to the signal arm.

When the balance lever is pulled from the end of its short arm, the displacement of the crank downwards is double that of the displacement which occurs when the balance lever is pulled at the end of the long arm. The length of the crank is calculated so that in the latter case the arm will come to the 45° position and consequently to the vertical position in the first case.

The balance levers coupled up to the disengaging balance levers are fitted with counterweights, for reasons which we have already pointed out.

The working of one of the counterweighted balance levers reacts on the other through the medium of the balance lever with unequal arms, ant it is clear that whilst the end of one of the counterweighted balance levers is pulled downwards when it is worked, the corresponding end of the second counterweighted lever is pulled upwards by means of the balance lever with unequal arms. The stop of the counterweighted lever on the carrier of the disengaging balance lever should oppose this displacement.

A lamp giving a double light is made use of, the direct light appearing white behind a transparent glass, whilst the reflected light appears behind an Isly blue glass showing green.

The triple spectacle is fitted with a yellow glass in the top and central roundels and a sheet iron plate to mask the light in the bottom roundel. To a prolongation of the top roundel, a sheet iron plate is rivetted, which in normal conditions covers the green light of the lamp, so that only the yellow light is visible when the arm is at danger, and also visible at the same time as the green light when the arm is inclined to 45°. Finally, it is covered and the green light only is apparent when the arm is vertical.

Working of a distant signal which repeats the indications of two other signals less than 800 m. (875 yards) apart. — The conditions for working are exactly the same as those for three-position signals, because passing the arm from 45° to 90° may happen when the distant signal having already been placed at 45° (whilst the second inner signal was still at danger), this second signal is then put to line clear only a short time before the arrival of a train. The driver of this train having already seen the distant signal standing at 45°, there can be no question of putting it back to danger and then immediately after place it at 90°, which would have to be done if a balance lever with unequal arms was made use of.

This case therefore ought to be dealt with in exactly the same way as that of the three-position home signal.

Numbered arms. — Figure 74 shows a balanced arm coupled up with eight numbers. The disengaging levers are fixed four by four on two carriers, and each disengaging balance lever crank is joined by means of a coupling rod to the frame containing the corresponding number. The number plates turn round on a common shaft on which also swivels a counterweighted framing containing all the numbers. Any required number is raised when its tail end is pulled down by means of the rod working it. On coming

down, this tail end pulls with it the frame, causing the latter to rotate round its shaft. The frame is joined to the signal arm by means of a vertical coup-

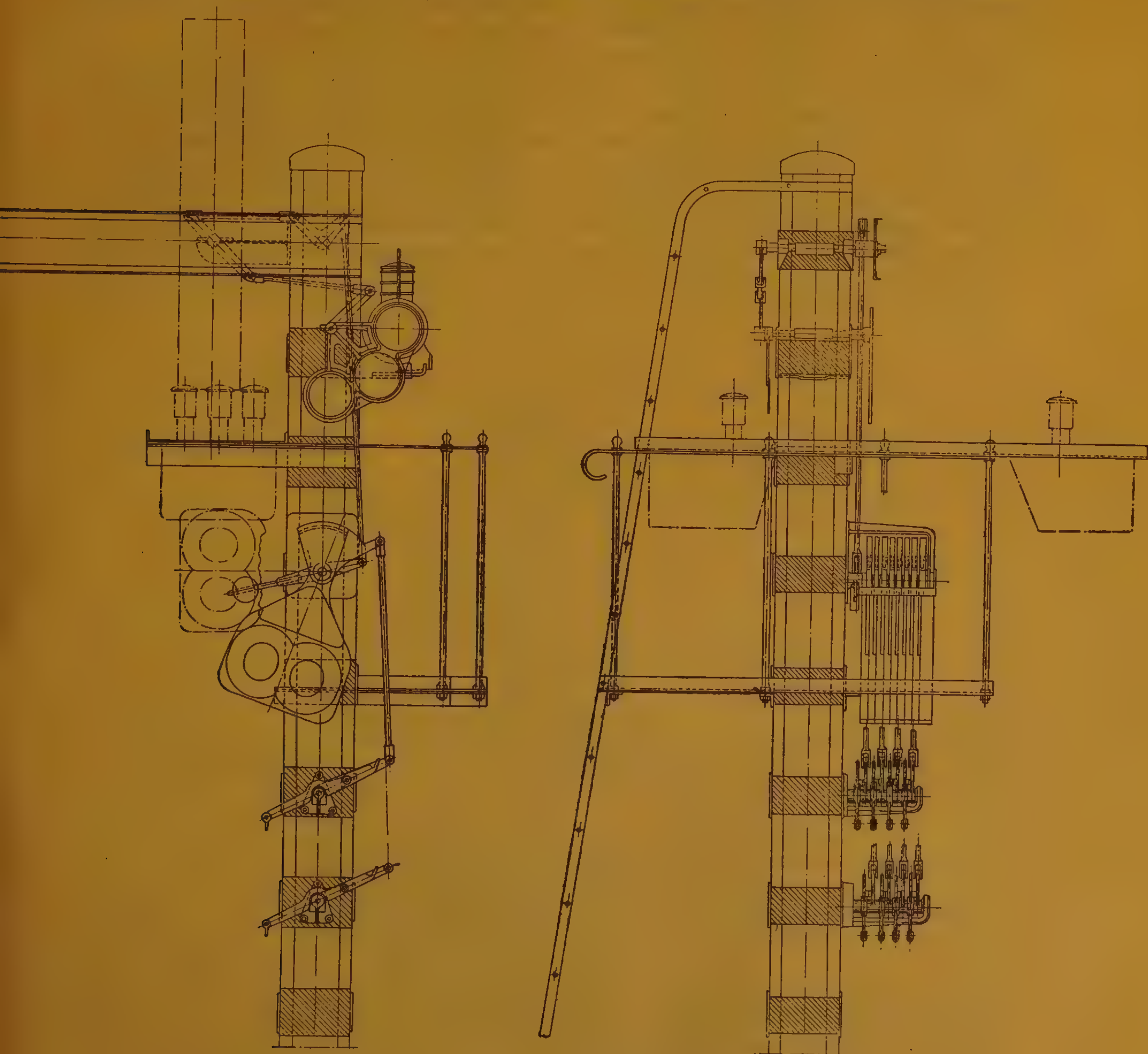

Fig 74. — Balanced signal arm coupled up with eight numbers.

ling rod, a bell crank, a horizontal coupling rod and a crank keyed to the signal arm.

On the opposite side to which the coupling rod is placed, this frame is provided with a balanceweight which rises when

the arm is placed at line clear, and is arranged so as to bring back the arm to danger in case a pull to danger wire should break. The numbers are painted on both sides of a sheet iron plate 2 mm. (0.078 inch) thick screwed on to a cast steel frame tail plate, and at night they are lit up back and front by special lamps fitted with three burners supported by a framing fixed to the post, to which is added a platform from which their mechanism can be examined.

Slotting the numbers (fig. 75). — When one number only is slotted, this may be done by inserting a Cesar's rotary slot in the run of the wire.

Generally speaking, however, semaphores which indicate numbers are used in large stations where transmissions by wire are often difficult to arrange, so that the slotting of the numbers is done electrically by means of a disengager inserted between the numbers and the signal arm.

One disengager only is necessary for

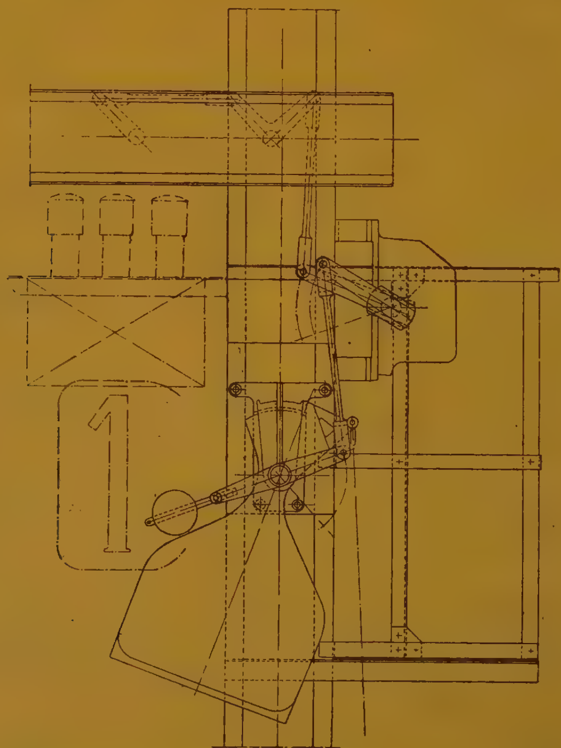

Fig. 75. — Slotting of an arm working with numbers accomplished by means of a disengager.

the slotting of several numbers. Slot cabins have an arrangement of switches inserted in the circuit of the disengager, and the selection of circuits is generally made at the local cabin by means of switches worked by the point levers.

Semaphores with two arms, one of

which is a distant signal. — There are three cases to consider according to the way the top home signal is coupled up :

1° To a distant signal rising to the 45° position only;
2° To a distant signal repeating the indications given at a junction bracket;
3° To a distant signal repeating the indications of two following home signals less than 800 m. (875 yards) apart.

These three cases are respectively shown by the conventional signs given by figures 76, 77 and 78, and in each one of them the home signal can be placed in three positions.

Fig. 76.

Fig. 77.

Fig. 78.

First case. — *Home signal coupled up to a distant signal rising to the 45° position only* (fig. 79). — This is the case of a semaphore fixed at less than 1 000 m. (1 100 yards) before coming to a junction

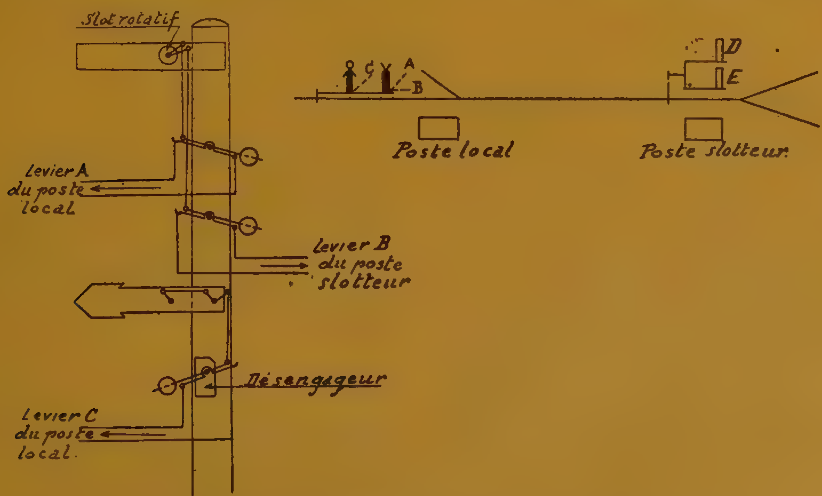

Fig. 79. — Diagram of the working of a three-position home signal coupled up to a distant signal which rises to the 45° position only.

Explanation of French terms : Slot rotatif = Rotary slot. — Levier A du poste local = Lever A of local cabin. — Poste local = Local cabin. — Poste slotteur = Slot cabin. — Levier B du poste slotteur = Lever B of slot cabin. — Désengageur = Disengager.

bracket on the two branches of which the trains must proceed at caution.

First hypothesis. — Let us suppose that the junction bracket is worked from a cabin which we will call « slot cabin », whilst the two-armed semaphore is worked from another cabin which we will call « local cabin ».

As shown in figure 79, the home signal is worked in three positions by means of a rotary slot fixed on the shaft on which the arm rotates, the 45° position being obtained by means of a lever A *in the local*

cabin, and that of 90° by a lever B *in the slot cabin.*

The distant arm is worked by a lever C in the local cabin and slotted electrically by means of a disengager.

At the slot cabin, an interlocking arrangement is fitted up between lever B and the levers of the junction signals, necessitating that first of all one of the latter must be placed at line clear, in order to allow lever B to give line clear.

On the other hand, the following interlocking must be arranged between levers A and C at the local cabin :

$$\frac{\cdot}{C} = \frac{\cdot}{A} \quad (1)$$

which requires that lever A should be reversed in order that lever C may be reversed in its turn. The distant signal cannot be placed at 45° until after the arm above it has been placed at 45°; but this is not all that is required, for it is necessary that the distant arm shall not be placed in the line clear position until the top arm itself is standing at 90°. In order to arrange this, the distant arm is slotted by means of a disengager, the electro magnet of which is inserted in an electric circuit comprising the switches worked by the arm of the home signal and those of the junction bracket in such a way that, in order for the electro magnet of the disengager to be excited and the distant arm be raised to the 45° position, the arm of the home signal must come to 90°, and one of the junction bracket arms shows line clear. Breaking the contact of one of the switches, which would result from placing one of these arms to danger, would demagnetise the magnet and cause the distant signal to automatically fall to danger.

A bell arrangement and disc indicator fixed in the local cabin are inserted in the circuit of the disengager and warn the signalmen, the electro magnet having been excited, that he can put the distant signal to line clear.

Second hypothesis. — If the junction bracket is worked from the same cabin as the two-armed semaphore, and if the bracket is neither slotted mechanically nor electrically, the disengager of the distant signal may be omitted by arranging the following interlockings between the levers A, B and C :

$$\frac{\cdot}{C} = \frac{\cdot}{A \cdot B}$$

(to reverse C, levers A and B must also be reversed).

In addition to this, interlockings must be arranged between lever B and levers D and E working the arms of the junction bracket. These interlockings will be as follows :

$$\frac{\cdot}{B} = \frac{\cdot}{D} + \frac{\cdot}{E}$$

(to reverse B one of the levers D and E must also be reversed).

The rotary slot is kept for the purpose of working the top arm on the semaphore fitted with the two arms.

Third hypothesis. — A third hypothesis may be taken into consideration, namely, that in which lever B cannot be placed in the slot cabin though the junction bracket is worked from it.

In this case the three levers A, B and C should be fixed in the local cabin and the arrangement made for the first hypothesis will be made use of besides inserting a second disengager to the coupling rod

(1) See article by J. Verdeyen : « On the practical study of interlocking » (*International Railway Association Bulletin*, February 1921, p. 196).

working the Cesar apparatus, which is itself worked by lever B. This disengager, the electro magnet of which is placed in series in the circuit of the disengager of the repeater, is excited before the latter is when the circuit is closed by the switches controlling the placing at line clear one of the arms D or E, and to the 45° position of the top arm of the semaphore provided with two arms.

The disengager of the distant signal arm is only excited later on after the vertical position of the top arm of the double armed semaphore has been checked by means of an additional switch.

Second case. — *Home signal working in conjunction with a three-position distant signal repeating the indications of a junction bracket* (fig. 80).

First hypothesis. — The vertical position of the top arm of the double armed semaphore is arrived at by working lever B in the slot cabin, and levers D and E in this box work the junction bracket arms corresponding respectively to the straight line and the branch line.

The top arm of the double armed semaphore is placed in the 45° position by means of lever A in the local cabin, and

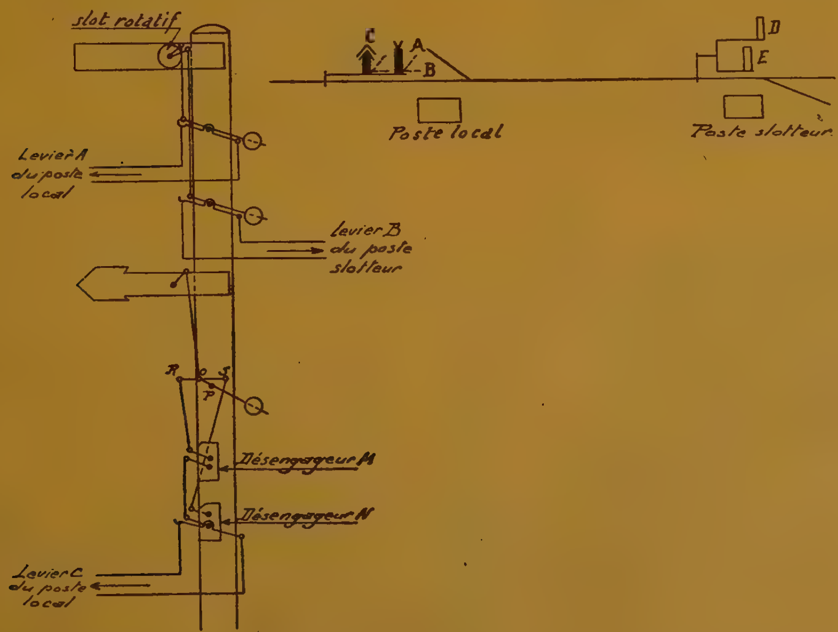

Fig. 80. — Diagram of the working of a three-position home signal coupled up to a three-position distant signal repeating the indications of a junction bracket.

Explanation of French terms : Slot rotatif = Rotary slot. — Levier du poste local = To lever of local cabin. Levier du poste slotteur = To lever of slot cabin. — Désengageur = Disengager.

the 45° or 90° positions of the distant signal by lever C worked by itself in the local cabin. The 45° position is obtained when the electro magnet of the disengager

N is alone excited and that of 90° when the two disengagers M and N are simultaneously excited at the time lever C is worked.

The top arm is put into its three positions through the medium of a rotary slot fitted to the shaft of the arm, and the distant arm is worked by a balance lever with equal arms RS which turns round spindle *o*, and coupled by means of this spindle to a counterweighted balance lever rotating round spindle P which is the only fixed point in the arrangement.

The following interlockings are obtained at the slot cabin :

$$\frac{\cdot}{B} = \frac{\cdot}{D} + \frac{\cdot}{E}$$

and at the local cabin :

$$\frac{\cdot}{C} = \frac{\cdot}{A}.$$

The disengager N is only exited when the circuit in which it is inserted is closed by the switches controlling : 1° the vertical position of the signal E, and 2° the vertical position of the top arm of the two-armed semaphore. A disc and bell arrangement fixed in the local box warn the signalman that the disengager is excited, and that lever C may be worked, and the bell does not stop tinkling until this is done. Lever C being reversed, its motion transmitted by the disengager N, pulls the extremity S of the balance lever RS downwards, which action through the displacement of crank PO places the arm in the 45° position. Observe that the disengaging balance lever fixed to the front face of the disengager N on being worked transmits its motion to the front crank of the disengager M, but the electro magnet of the latter not being excited, the motion has not been communicated to the back crank of the disengager.

The electric circuit of the disengagers is combined in such a way that the two disengagers M and N are simultaneously excited when the circuit is closed by means of the switches controlling the vertical position of the arm D belonging to the slot cabin at the same time the top arm of the two-armed semaphore is in the vertical position. The disc indicator and the bell arrangement inform the local cabin of the closing of the circuit, and the bell does not cease tinkling until the signalman reverses lever C. The disengaging balance lever of the disengager N is then reversed, and the two disengagers being then excited, the extremity S of the equal armed balance lever is drawn downwards by means of the back crank of the disengager N, *at the same time as the extremity R of the same balance lever*, which is pulled by the back crank of disengager M.

Thanks to this simultaneous action on the two ends of the equal armed balance lever, the point *o* descends this time double the distance that it did previously when the balance lever was only pulled down by its extremity S. This simultaneous action on the two extremities R and S of the balance lever has the effect of bringing the repeating arm into the vertical position.

Second hypothesis. — The junction bracket and the two-armed semaphore are worked from the same cabin, and the arms of the junction bracket are not slotted.

The rotary slot is kept for working the top arm of the two-armed signal, and the two disengagers of the repeating signal are replaced by a *balance lever with unequal arms.* The lever C working alone is replaced by the two levers C′ and C″, which give to the distant signal the 45° and 90° positions.

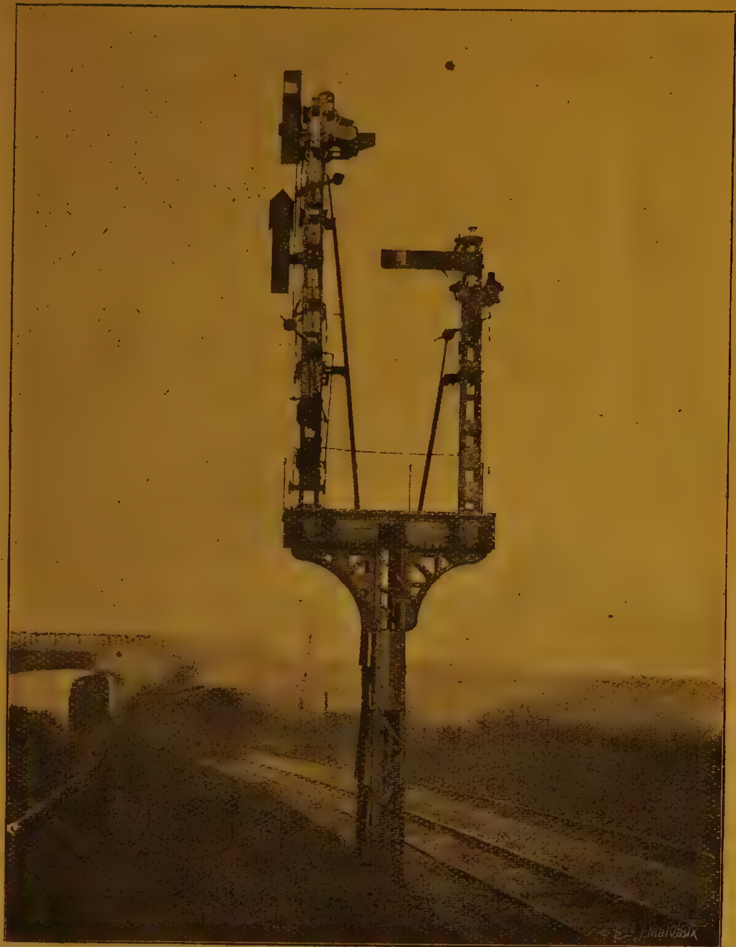

Fig. 80*bis*.

Fig. 80*ter*.

Figs. 80*bis* and 80*ter*. — Junction bracket; the taller post is fitted with a three-position signal working in conjunction with a three-position distant signal. These two arms are operated by the arrangement shown in figure 80.

The following interlockings are obtained :

$$\frac{\cdot}{B} = \frac{\cdot}{D} + \frac{\cdot}{E};$$

$$\frac{\cdot}{C'} = \frac{\cdot}{A \cdot B \cdot E}; \quad \frac{\cdot}{C''} = \frac{\cdot}{A \cdot B \cdot D}.$$

Third hypothesis. — The junction bracket and the two-armed semaphore are worked from different cabins, but it is not possible to work from the slot cabin the top arm of the two-armed semaphore (for passing from the 45° to the 90° position).

The solution of the first hypothesis will be made use of (working the distant arm by means of a solitary lever C and the use of two disengagers M and N). A third disengager is inserted in the coupling rod working the Cesar slot coupled up to lever B.

The interlockings of levers A, B, C, which are in the same cabin, will be as follows :

$$\frac{\cdot}{C} = \frac{\cdot}{A \cdot B}.$$

The same electrical circuits will be used as in the first hypothesis, but slightly altered by the introduction of disengager P which will be excited before N as soon as the circuit is closed by the switches controlling : 1° placing at line clear either D or else E; 2° giving line clear at the 45° position of the top arm of the two-armed semaphore.

Exciting the disengager P allows the line clear at 90° to be given to the latter arm, and the electrical control of this position afterwards allows either the disengager N or simultaneously the disengagers M and N to be electrically excited.

Third case. — *Home signal working in conjunction with a three-position distant signal and repeating the indications of two other following home signals less than 800 m. (875 yards) apart* (fig. 81).

First hypothesis. — Semaphores *n* and *o* on the one hand, and the two-armed semaphore on the other, are dependent on two different signal cabins.

The home signal arm of semaphore *m* is placed in the positions 45° and 90° respectively by means of levers A in the local cabin and B in the slot cabin through the medium of a rotary slot fixed on the shaft of the signal arm.

The distant signal arm of semaphore *m* is operated by means of a balance lever with two equal arms worked by levers C and D in the local cabin with the aid of disengagers N and M.

Contrary to the first hypothesis in the preceding case, two levers are necessary for working the distant signal, for this must be able to pass from the 45° to the 90° position, having been first of all placed in the first position, when the semaphore *o* being at danger, the latter is afterwards placed in the line clear position.

The following interlockings are obtained :

1° at the slot cabin :

$$\frac{\cdot}{F} = \frac{\cdot}{G}; \quad \frac{\cdot}{B} = \frac{\cdot}{E};$$

2° at the local cabin :

$$\frac{\cdot}{C} = \frac{\cdot}{A}; \quad \frac{\cdot}{D} = \frac{\cdot}{A}.$$

Disengager N is only excited when its electric circuit is made by the switches which control: 1° the 45° position of the arm of semaphore *n*; and 2° the 90° position of the semaphore *m*.

The signalman of the local cabin is warned by means of a disc indicator and a bell arrangement that the disengager N has been excited, and the bell ceases to

tinkle when he works lever C. Thanks to the disengager N being excited, his action pulls the extremity S of the equal armed balance lever down, which causes lever OP to turn and place the distant arm in the 45° position.

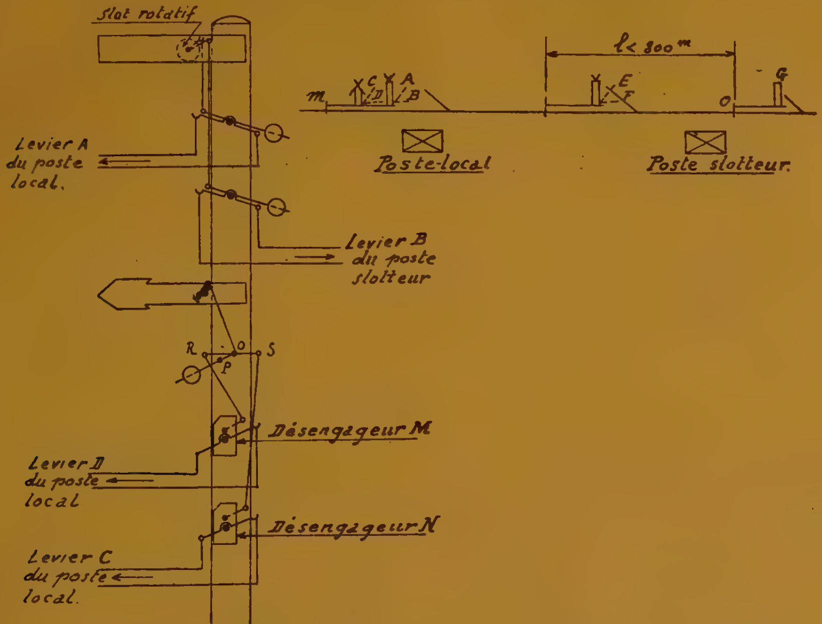

Fig. 81. — Diagram showing the working of a three-position home signal working in conjunction with a three-position distant signal repeating the indications of two signals situated in front and less than 800 m. (875 yards) apart.

Explanation of French terms : Slot rotatif = Rotary slot. — Levier du poste local = To lever of local cabin. Levier du poste slotteur = To lever of slot cabin. — Désengageur = Disengager.

The two disengagers M and N are excited simultaneously when the electrical circuit controls the *vertical* position of the arm of semaphore *n* and the vertical position of the top arm of semaphore M. In these conditions the bell tinkles in the cabin until both levers C and D are worked. On account of the two disengagers being excited, this double action has the effect of lowering the two extremities of the equal armed balance lever and bringing the distant signal arm into the vertical position.

Second hypothesis. — The three semaphores are worked from the same cabin, *n* and *o* not being slotted.

The top arm of semaphore *m* is worked by means of a rotary slot and the distant signal of the same semaphore by a balance lever with two *equal arms.*

The following interlockings are obtained when working from one cabin only :

$$\frac{\cdot}{F} = \frac{\cdot}{G}; \quad \frac{\cdot}{B} = \frac{\cdot}{E}; \quad \frac{\cdot}{C} = \frac{\cdot}{A \cdot B \cdot E};$$

$$\frac{\cdot}{D} = \frac{\cdot}{A \cdot B \cdot F}.$$

Third hypothesis. — Semaphores *n* and

o on the one hand, and m on the other are worked from different cabins, but contrary to the first hypothesis, lever B, which cannot be worked from the slot cabin, is placed in the local one.

As with the similar hypothesis in the two preceding cases, the solution of the first hypothesis is followed, but modified by the insertion of a third disengager P in the coupling rod of the rotary slot worked by lever B.

The distant signal arm is worked by means of an equal armed balance lever and two disengagers M and N, and the following interlockings are obtained in the local cabin :

$$\frac{\cdot}{C} = \frac{\cdot}{A \cdot B} \quad \text{and} \quad \frac{\cdot}{D} = \frac{\cdot}{A \cdot B}.$$

Exciting disengager P precedes that of disengagers M and N and takes place when the electric circuit is closed by the switches controlling the 45° position of the arm of semaphore n and the same position of 45° of the top arm of semaphore m.

Exciting disengager P allows the latter arm to be placed at 90°, and it is by closing the switches controlling the latter position that the exciting either of disengager N or simultaneously the disengagers M and N may take place later on, thus allowing the repeating arm to be placed respectively in the 45° and 90° positions.

New arrangement for working two-armed semaphores, one of which is a distant signal (fig. 82). — When the top arm is vertical, the distant arm should be either at 45° or else at 90°, there is therefore a lack of agreement in the indication when the top arm is vertical, whilst the distant arm is in the horizontal position, the vertical position of the home signal indicating that the following signal is at line clear, whilst the horizontal position of the distant signal indicates that it is at danger.

This defect in indicating may happen with the working arrangements just described, because placing the distant signal at line clear is done after the home signal has been placed in the 90° position.

The signalman may neglect putting the distant signal to line clear, or even simply wait too long before doing so.

As far as safety is concerned, this disagreement in the indication is not of great importance, for at any rate it only occurs when the following signal is showing line clear, and could hardly cause the driver to slow up when there is no reason for him doing so. Nevertheless, in order to avoid this happening, it is advisable that both arms should be worked simultaneously, and the Administration of the State Railways is trying a new arrangement, shown in figure 82, by which this simultaneous action can be obtained.

The whole arrangement is manipulated by means of two hand levers A and B in the local cabin, the top arm being worked through the medium of an equal armed balance lever OP, and the lower arm through the medium of an equal armed balance lever RS.

By working lever A, the extremity O of the balance lever OP is pulled down and the top arm is placed at 45°. When lever B is worked we get : 1° no motion transmitted to the arm if the two disengagers are not excited; 2° if only disengager M is excited (which happens when its circuit is closed by the switches controlling the placing of the arm F of the bracket y in the line clear position, and the 45° position of the top arm of semaphore x), the action of the disengaging balance lever, worked by lever B, is transmitted by means of the back crank of disengager

M to the extremities S and P of the two balance levers RS and OP, the result being to place the distant signal arm to 45° and at *the same time* passing the top arm from 45° to 90°; 3° if the two disengagers are simultaneously excited (which happens when their circuit is closed by the switches controlling the vertical position

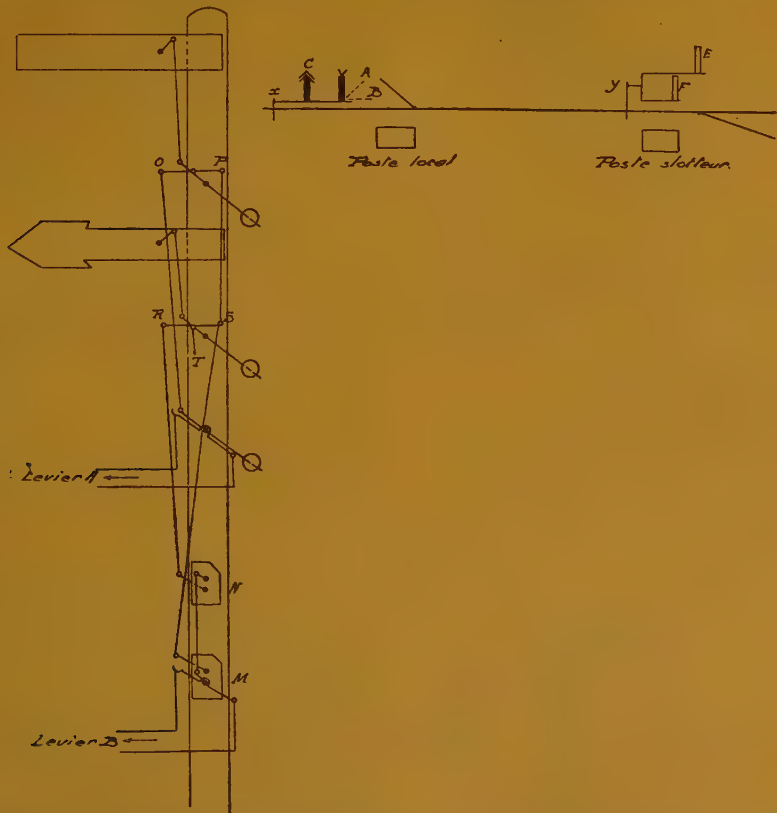

Fig. 82. — Diagram of the new arrangement for operating a three-position home signal working in conjunction with a three-position distant signal repeating the indications of a junction bracket.

of arm E on bracket y, and the 45° position of the top arm of semaphore x), the motion communicated by lever B to the disengaging balance lever of the disengager M is transmitted by the back cranks of the disengagers M and N respectively to the extremities P and S of the two balance levers OP and RS, as well as to the extremity R of the latter, so that the top signal will be placed in the vertical position at the same time as the distant signal.

To put a final touch to this arrangement, the case has been provided for when, on account of some unforeseen incident, a break down should occur in the working of the disengager M after the disengager N has been excited. The consequence of working lever B would

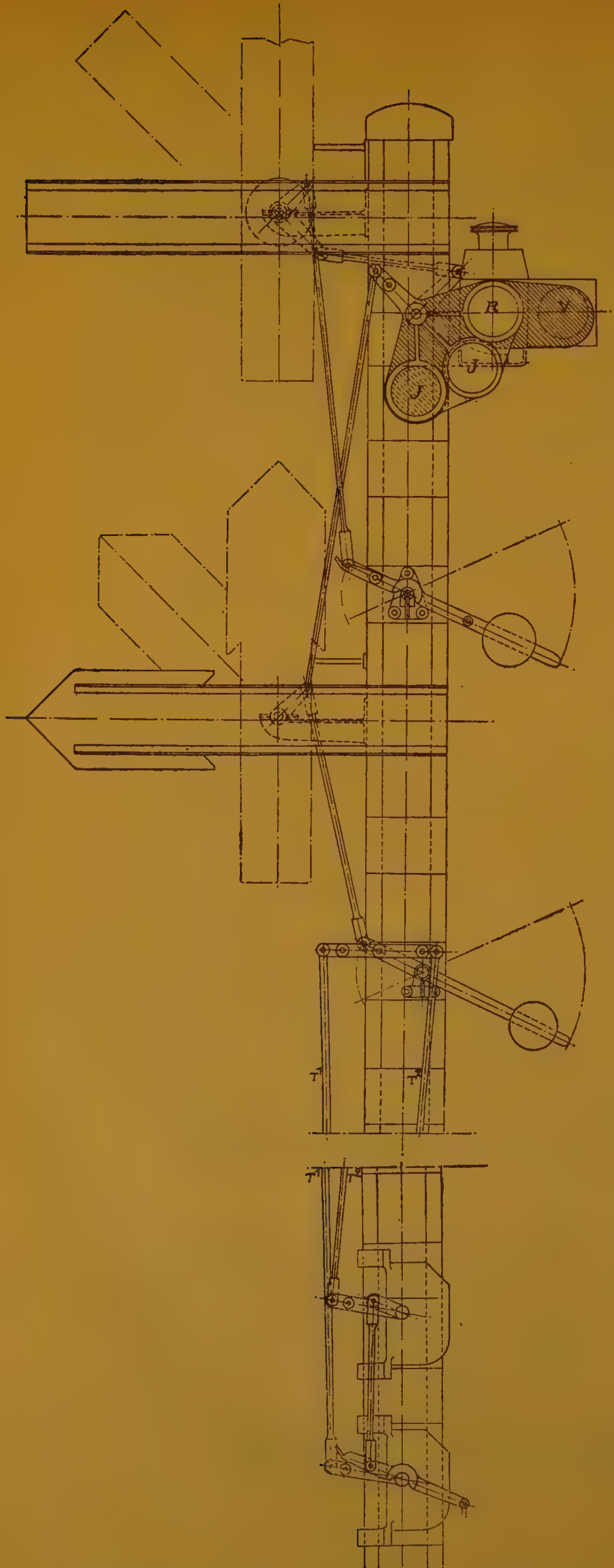

Fig. 83. — Two-armed semaphore built according to the indications shown diagrammatically in figure 80.

then be to pull down the extremity R of balance lever RS and to place the distant signal to 45° at the same time the top arm is in this same position of 45°.

In order to avoid this happening, the balance lever RS is fitted with a third arm T, which in case the end R *only* is pulled downwards, it would open a switch inserted in the circuit of the disengager N, which would then cease to be excited and so cause the distant arm to fall.

This arrangement has so far given excellent results on trial.

Construction of two-armed semaphores (fig. 83). — The parts which are used for building up two-armed semaphores are the same in every respect as those used in the construction of one-armed semaphores. One new device, however, is used which is independent of the triple spectacle frame in order to obtain the light required; this is the mask.

One lamp only is used showing two lights and placed a little below and to the right of the top arm. This lamp is fitted with a plain white lense placed directly in front of the flame and an Isly blue glass placed in front of the reflected light.

The triple spectacle frame, which is worked by the home signal arm, is fitted with a red glass in its top frame, and with yellow glasses in the two other frames.

A sheet iron mask placed behind the spectacle and turning freely on the rotating spindle of the screens may be raised and turned in the same direction as the spectacle frame itself. This mask is worked, *at the same time as the distant signal arm* by means of a coupling rod jointed at its bottom extremity to the crank working this arm.

The two arms being at danger in their normal position, the green light of the lamp is hidden by the mask, and the red

light of the triple spectacle is alone visible. The top arm being at 45° and the bottom one horizontal, the green light of the lamp is always covered, and the yellow light given by the central spectacle frame is shown. When the top arm is vertical and the bottom one at 45°, the yellow light given by the bottom glass of the frame appears at the same time with the second green light of the lamp, its mask having been raised by the distant arm.

Finally, when the two arms are vertical, the mask hides the direct light, whilst the green light appears by reflection through the Isly blue glass of the lamp.

Shunting signals. — The small signal arms for shunting purposes are made and worked in the same way as ordinary arms.

Operating a small three-position signal arm is accomplished by means of a balance lever with unequal arms. Sometimes, however, when the signal is very close to the cabin, and circular levers with a long stroke are used in it, the three positions of the warning arm can be obtained exactly by means of one lever only worked with two movements. A notch cut in the frame at half travel determines the position of the lever when the arm is inclined at an angle of 45°.

[625 .142.2 & 691]

Creosote shortage threatens wood preservation,

By C. M. TAYLOR,

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(*Railway Age.*)

The increasing cost of creosote oil presents a problem to those engaged in wood preserving which would be serious enough if expense alone were involved; but the graver question of a shortage presents an issue that should be faced fairly, and promptly, if the 80 million ties that should be treated chemically every year are to be preserved.

Examples of ties treated successfully with oils of unknown origin or composition mark the early days of wood preservation. For instance, some ties were treated for the Central Railroad of New Jersey in the 70's with a preservative which was called « Still Bottoms » which was apparently of petroleum origin. They were in track for over twenty-five years and contained preservative enough to prevent decay indefinitely if the mechanically destructive agencies responsible for their removal had been properly controlled.

That this and other examples of ties treated with oils other than creosote have not been duplicated generally is because the chemical and toxic properties of such other oils have long been indetermined, and because so long as dead oil of coal tar, called creosote, continued available, cheap, and satisfactory it was used freely and the question of substitute oils was not considered. Furthermore, the « safety-first » idea of pure creosote oil was carried to a « pure-food-law » extent, until engineers generally have been educated to the belief that nothing but pure creosote oil should be used as a preservative for ties. The psychology of the situation lies in the fact that to date all attempts at specifications have been to fit the creosote oil produced, rather than to fix the manufacture of an oil for the use intended. Consequently a pure product has been specified on the supposition that only with such a one could there be safety and satisfaction in its use. However, no positive chemical or physical analysis has been developed to date which will prevent circumvention of the standard specifications if a manufacturer desires to deceive, and therefore oils not distilled from pure coal tar have been palmed off as pure creosote, creating in the industry a situation, too long tolerated by some and fostered by others, which has been excused on the score of the chemical complexity of pure creosote and its economic status.

Through the technical supervision of their treating operations railroads have discovered that oils delivered as pure coal tar creosote contained water gas tar or water gas creosote.

Despite clamor against water gas tar by certain creosote oil interests and their allies, who were asserting how inferior it was for wood preserving purposes and how its presence must be guarded against at any cost in the purchase of creosote oil, large amounts of water gas tar were at the same time being mixed with creosote oils and sold under labels and prices which fully warranted the consumer in believing that pure creosote oil was being obtained.

To see so much water gas tar produced in this country as such and to know that it lost its identity and eventually came forth as coal tar creosote should create the impression that much assumed in the past about the sanctity of pure coal tar creosote has been based on faith rather than fact.

Condemning water gas tars on one hand and selling them in mixture with creosote oil on the other could not last forever, especially since some large railroads have been knowingly and openly using such mixtures with signal success for years.

Fortunately there are ties treated with pure water gas tar creosote oil which are in just as good condition, from the standpoint of preservation, as when they were installed, which controverts the idea so actively put forth that the only way to get results is to use pure creosote oil, because it was toxic, had tar acids in it, and, to be further sure, it had some high boiling compounds which were not only permanent but apparently toxic also.

The old idea that tar acids must be present in oils is having to be revised, and failure to take cognizance of the lack of necessity for it is to hide our heads in the sand. According to Bulletin 1036 of the U. S. Forest Products Laboratory, high temperature oil tars (of which water gas tar is practically the sole example) are « characterized by the almost entire absence of tar acids and tar basis ».

The satisfactory results from the use of pure water gas tar creosote for several years by the Public Service Railway of New Jersey should be evidence enough that water gas tar, far from being a detriment in the preservation of wood, has a rightful place as a wood preservative. Notwithstanding the steadily accumulating evidence as to the wood preserving value of water gas tar creosote, railroads are being advised to avoid its use. The maintenance of this position is worthy of note in view of the common knowledge that large quantities of material mixed with coal tar creosote were used in the past with excellent results. Some railroads have used water gas tar in mix with zinc chloride in the Card process, with results which vary from excellent to not so gratifying. No water gas tar oil meeting the A. R. E. A. specifications for the Card process has been reported as having proved unsatisfactory.

Due to the competition for their use in conjunction with or as road oils, water gas tars and water gas creosotes have risen in price, so that it is now impossible to buy them at prices much under those for coal tar products except when at certain times in the winter the limited storage facilities at most water gas tar plants force these tars on the market and they may be obtained at figures slightly lower than those for coal tars.

Since enough water gas tars or oils to be diluted with or substituted for creosote oils cannot be had, other diluents, which some authorities consider better fitted than either coal gas or water gas tars, come into consideration. These are certain grades of petroleum oils.

In 1910 a paper before the American Wood-Preservers' Association gave the practice of one large railroad. Since that time another trans-continental road has used a mixture of crude petroleum and creosote and coal tar, a heavy combination but a usable one when the penetration is restricted as in Jack Pine, Mountain Douglas Fir, and such species having thin sapwood. To some the mixing of creosote oil with petroleum oil appears like opposing the trend of developments, which have seemed to tend toward more detailed attempts to get a pure coal tar creosote. But is it really in opposition to actual developments?

Creosote oils obtained from coal tar produced at recently established coke-ovens do not generally meet the present

requirements of the American Railway Engineering Association. The present specifications applied to some oils imported into this country some fifteen or twenty years ago would not permit their classification today as pure creosote oils. Furthermore the tendency is to produce lower temperature tars and these tars, whether originating in coke ovens or from recent developments in an attempt towards more economical gas production, will certainly make available large quantities of tars, which will not produce creosote according to our present recommended practice. These changing conditions in the production of pure coal tars alone will require intelligent revision of our standards if we should continue to demand pure coal tar creosote for preservation of cross-ties. Some of the low temperature coal tars run high in phenoloids and have considerable quantities of paraffin hydrocarbons.

To continue to treat cross-ties with pure coal tar creosote oils seems to be a waste, and the use of cheaper mixtures with certain petroleum oils has given results which justify its adoption by railroads. There seems good reason for believing that a 50-50 mixture of creosote oil and petroleum oils of the proper character can be relied on to prevent decay in any tie that is sound when accepted, properly seasoned for treatment, and thoroughly and evenly penetrated throughout its penetrable portions with an average of 6 pounds of the mixture per cubic foot.

Although cheapness alone would be sufficient warrant for the adoption of the creosote crude oil mixtures, there is a further great benefit to be gained by their use, and that is their wonderful fiber binding quality, as seen in a recent survey of the situation during which thousands of ties were examined. The usual brooming of the fiber seen in ties treated with zinc chloride varies with the different kinds of wood, but almost all zinc chloride treated ties have a dried out appearence, and in time the annual rings separate and the fibers of each ring come apart. This results in reducing the mechanical life of the tie and also increases the leaching of the preservative. The Card process did much to counteract this leaching and also worked wonders in fiber binding compared with the Burnett process.

Creosote oil used alone has proved a still better fiber binder and its superiority despite its greater cost is generally acknowledged; however it has been used in excess of any requirements for the prevention of fungus growth. Its fiber binding qualities vary with different creosote oils, depending on their origin and pitch content. If the pitch residue eventually becomes so hard as to be brittle, very little good is had of it. These properties have been generally lost sight of or not sufficiently appreciated because the end desired was not always understood and consequently not aspired to.

Yet mixtures of creosote oil and certain grades of petroleum oil seem to give better results in fiber binding than any of the pure creosote oils. Thousands of mixture treated ties in track with creosote oil treated ties show how much better preserved mechanically the mixture treated ties are, and provide sufficient evidence that the use of certain grades of petroleum oils mixed with creosote oil is not only a cheaper but a better proposition. Furthermore the protection against wood-destroying fungi by the creosote crude oil mixtures seems to be just as efficient as when straight creosote oil is used.

However, even if coal tar creosote oil is considered necessary as a basis for mixtures with petroleum oils, there is adequate assurance of safety if there is toxicity equivalent to one-fifth of a pound of creosote oil per cubic foot, the work of the Forest Products Laboratory proving this a minimum which would inhibit the growth of *Fomes annosus*

a virulent type of wood-destroying fungi. Dean and Downes have developed supporting data along these same lines.

Millions of ties have been treated in this country with an average of 5 pounds of creosote oil per cubic foot, and a reasonable evaporation factor of 50 % at the end of ten years would leave only 2 1/2 pounds per cubic foot, which means that any wood which has been thoroughly impregnated with creosote oil, no matter how great the evaporation, no matter how little oil was required to impregnate the wood thoroughly, such treated wood has proved satisfactory. From the above it begins to look as if ties have been over-treated from a toxicity standpoint. 3 pounds of creosote properly distributed has saved thousands of ties from decay and anything in excess of 3 pounds of creosote per cubic foot is first a factor of safety and second a fiber binder.

Much confirming data of the successful preservation of ties with the use of such small quantities of preservative oil thoroughly permeating the treatable portions of the ties can be had from individual tie weighings in connection with the installation of test sections on various railroads.

Past and present objections to so-called blast furnace oils, which run rather high in tar acids are sometimes based on failures supposed to be due to the use of blast furnace oils. These oils were used successfully in timber treatment for years, but owing to trade antagonisms have not been used so largely of late. There is no reason why, if toxicity is required in wood preserving oils and if the price is right, coal tars, water gas tars or petroleum oils cannot be combined with blast furnace oils in efficient and economical mixtures containing sufficient toxic properties, etc., to meet the general average requirements and at the same time be relatively permanent.

Merely mixing any creosote oil with any petroleum oil is not the proper procedure, however. Some creosote oils mix easily with some petroleum oils and the mixture can be used readily and held in proper equilibrium by air agitation in the working tanks. Certain oils, however, are prone to precipitate a residuum when mixed with creosote oils, and crude oils having this tendency to a serious extent should be avoided. What is needed is an oil containing sufficient residue of such consistency that it will continue plastic enough throughout the life of the tie to act both as a fiber binder and as a moisture barrier, in addition to its preservative quality.

It will be remembered that the report of the Committee on Preservation of Timber, presented and accepted at the annual convention of the American Society of Civil Engineers in 1885, mentioned that even paraffin base oils saturating ties already in track extended the life of inferior woods several years. Also, in the recent developments of oil spraying of rail and track fastenings, much beneficial effect is noted where the oils spray the surface of the ties.

The problem of knowing when a safe and workable mixture oil is had will be a matter for chemical determination. The fact that such oils have been used successfully for years should be sufficient evidence that, when properly performed, the work of mixing and injecting them can be handled satisfactorily. The problems of temperatures and pressures to be used have to be studied as was the case when the industry began to absorb creosote oil mixed with coal tars and water gas tars.

When creosote oil is not available, the toxicity lacking in some crude oils can be supplied by mixing the latter with zinc chloride, calcium chromate, sodium fluoride or some other toxic medium. Water gas tar creosote and certain grades of low temperature tars can be mixed with crude oils and used with assurance of successfully preserving ties.

So far there is no known example of a failure from decay of a creosote crude oil mixture treated tie. The above leads to the conclusion that railroads need not depend entirely upon creosote oil alone for their tie preservation. Any of the mixtures mentioned could be made available promptly at a reasonable cost.

[656 .257 (.42)]

Route signalling at Winchester, Great Western Railway.

Figs. 1 to 6, pp. 701 and 704.

(*The Engineer.*)

The benefits of the power operation of railway points and signals are well known, and there is little necessity for their recital. Briefly, they are : 1° the locking frame is about one-third the ordinary length; 2° the consequently smaller signal-box may be placed in any position, as there is no point rodding or signal wires to « lead away »; 3° there is no limit to the distance points may be from the box; and therefore 4° one box can do the work of two or three mechanically operated boxes; 5° no manual exertion is necessary for the movement of points and signals; and 6° the exact normal and reverse positions are guaranteed. Route signalling goes, however, still further, as the movement of one lever will reverse or, hold at normal, the necessary points for a route and then lower the requisite signal. There is, therefore, yet greater economy than in power signalling, and in a case in our mind, where forty levers are necessary for mechanical signalling, twenty-eight would be required for power signalling, and only seventeen levers for route signalling.

At Winchester, where the Ferreira-Insell plant has been installed by the Great Western Railway, the signalling is as shown in figure 1. The frame contains only sixteen levers—the numbers 17 to 22 are not, as will be explained directly, in the frame. Were this box manually operated the number of working levers in the frame would have been twenty-five, and with power signalling twenty-one working levers would have been required.

Electricity at 120 volts is the power employed for the operation of the points and signals, and is controlled at 24 volts by contacts on the respective levers. The levers, in turn, are controlled by track circuits. There are five track circuits, and the presence of a train or vehicle locks the levers, and therefore holds the road, as indicated below :

Track circuit.	*Locks lever.*
A.	1, 7, 10, 15 (6, 13 when 18 or 19 is over).
B.	6, 7, 10. 13, 15.
C.	1, 7, 10 (8, 11 when 20, 21 normal; 15 when 21 normal).
D.	2, 3, 4, 5, 12, 16.
E.	prevents 8, 11, when over, being restored.

Each lever is pulled over in two stages. When back in the frame it is in what is known as the « Normal » position. The first and shorter stroke takes it to the « Route » position, and the second and longer movement com-

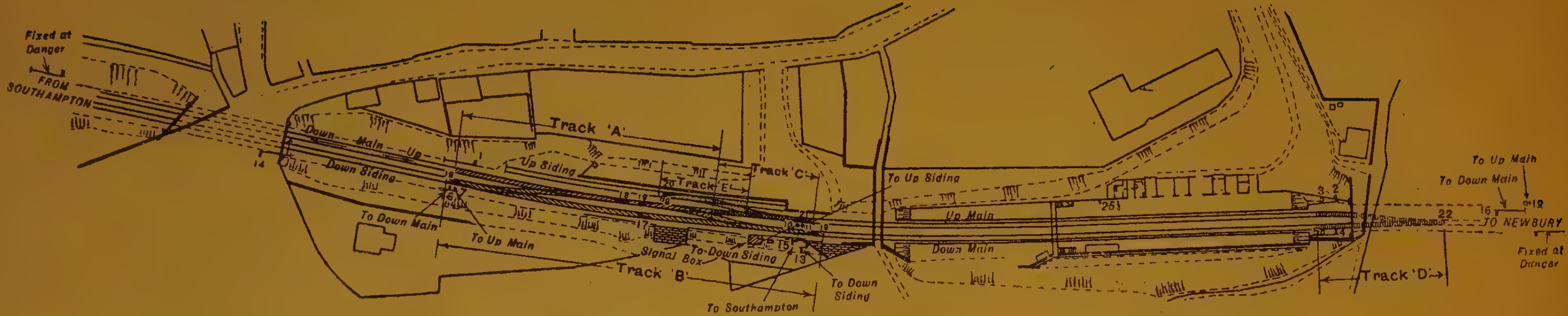


Fig. 1. — Route signalling arrangements at Winchester.

Fig. 2. — Interior of signal-box at Winchester.

Fig. 3. — Lay-out of points.

pletes the stroke and takes it to the « Signal » position. There are two similar movements in the reversal of a lever. The first and shorter takes it from « Signal » to « Track », and the second and longer from « Track » to « Normal ». Thus, in pulling over a lever, the «Track» stage is omitted, and in the lever's return the « Route » stage is passed over.

Referring to the photographic reproduction (fig. 2) illustrating the interior of the signal-box, the miniature character of the locking frame and its levers will be appreciated. Behind the levers are four rows of lights. The uppermost row has red lamps, the second green, the third orange, and the lowest white. Normally the uppermost (red) is shown. When a lever is moved, if the track be clear, the white light is switched in also; if the track be fouled no white light appears. Thus, should an up train, standing at the up platform, have its tail on track C, so fouling the path for a down train leaving for Southampton, the bottom light behind lever 15 would not appear, thus advising the signalman that the lever was locked and it was no use to attempt to move it beyond the « Route » position.

If a lever be free the shorter stroke from « Normal » to « Route », by making the necessary contacts at 24 volts, operates the appropriate point contactors which cause current to be sent to the points concerned, and if any points be not in their correct position they are moved to suit the proposed movement. Thus, again taking lever 15 for an example, it would ensure that points 17 were normal and set for a trap against anything leaving the down siding. It would also make the nearer end of 18 lie for the main line with its further end acting as a trap. It would also set 19 to allow for a movement from the down main to the single line and reverse 21 so that it lay towards the up siding and acted as a catch point to prevent anything backing off the up main line.

When all this has been done — the point movements being made concurrently and not in series — the second indicator is illuminated and the orange light shown signifies that the route is made. A check lock that has prevented the full stroke of the lever to « Signal » is simultaneously withdrawn; the completion of the stroke which lowers the signal then becomes possible, and the red light is switched out and the green light appears.

The restoration of a lever has not quite the opposite effect. As already said, it can only go from « Signal » to « Track ». This action restores the signal, but does not change the position of any of the points. When the signal is again at « danger » the green light changes to red. This does not, however, permit of the backward stroke of the lever being completed as long as anything is on the track circuits concerned — a condition indicated by the white light being out. Thus, whilst 15 may be put from « Signal » to « Track », and the signal put to « danger », its stroke cannot be completed until the train is off tracks A and B. In just the same way, when any one of signals 2, 3, 4, 5, 12, or 16 have been used it may be put to « danger », but the full stroke of the lever cannot be made until track D is clear. Obviously, this condition dispenses with the necessity for facing-point locking bars. When, however, the tracks concerned are clear the white light is again seen and the lever may be fully restored. When restored, the white light disappears.

Those points — *e. g.*, 17, 18 and 20 — which are safety points and prevent trains and vehicles leaving sidings, are restored so as to act as traps; but, for instance, the replacement of 15 would not restore 19 nor the restoration of 2 or 3 cause 22 again to lie for the down main line. As long as the safety points are put to normal the other points may lie as they are and power be saved that

would be used were they reversed, and, later, had again to be moved over.

Provision for individual operation.

On the lower front of the locking frame are six slides, numbered 17 to 22 inclusive, which are employed for the separate working of individual points for cleaning or other purposes. They, too, have indications which show the signalman the position in which the points are lying and that they are obeying the lever. When they lie as seen on the diagram in the signal-box, and in figure 1, a green light is shown. When points which also serve as safety points — *e. g.*, 17, 18, 20 — are not lying normal, and therefore not acting as safety points, the indication is red instead of green, but the red is only switched in when the points are changed and are not acting as safety points. For points the position of which is immaterial — *e. g.*, 19, 21, 22 — the alternative indication is orange.

In the event of his being unable to set up a route, indicated by the non-appearence of the yellow light, the signalman can test the different points by these slides. He must, however, first pull king lever No. 9 — seen partly over in figure 2 — from its normal « Route » position to « Signal » position. This action will lock every signal at « danger » — incidentally, the lever cannot be pulled if any signal be at « clear » — and release all the point slides. Such of these as are necessary can then be pulled to ascertain where the obstruction is. When put right and the slides restored, the king lever must again be put to the « Route » position. In case a lever cannot be restored from te « Track » to « Normal » position, owing, for instance, to the track relay failing to pick up, the king lever may be pushed from the « Route » to the « Normal » position, and this action will release the lever in question. The king lever must then again be put to the « Route » position, because, as already said, all signals are locked unless it is normal.

Interlocking.

The fact that there are no independent point levers in the frame makes it necessary to arrange the interlock in an unusual manner. For instance, no interlocking is effected between signals through points. Ordinarily, for instance, No. 1 signal would lock points 20, and as signal 8 would require 20 there is no necessity for 8 and 1 to be interlocked. Or, again, as 2 and 3 would require 22 and 4 and 5 would lock 22 there is no need to interlock 2 and 3 with 4 and 5. All this is altered, and signal 1 locks signals 7, 8, 10, 11, 12, 14, and 15, and king lever 9. Points 18, 19, 20, and 21 are also interlocked, but by the route lever arrangement. Actually there appears greater freedom by this manner of interlocking.

Where this type of lever movement is convenient is that when a signal has been lowered and the lever is restored to « Track » position other levers that would be locked when the lever was in the « Signal » position would be free when in the « Track » position, even with the track occupied, provided no alteration of route were required. Thus, when an up train had to attach a horse box standing in the up siding No. 11 lever would open 20 and 21 points. The replacement of 11 to « Track » would put the signal to « danger », and although the lever was partly over, No. 8 lever could be pulled to lower that signal for the train to return to the main line.

Again, signal 1, after being lowered and then restored, is locked in « Track » position when signal 2 is at « clear » by its lever being in « Signal » position. This arrangement ensures that 2 must be restored before route No. 1 can be interfered with. Signal 12 does the same with the routes of levers 10 and

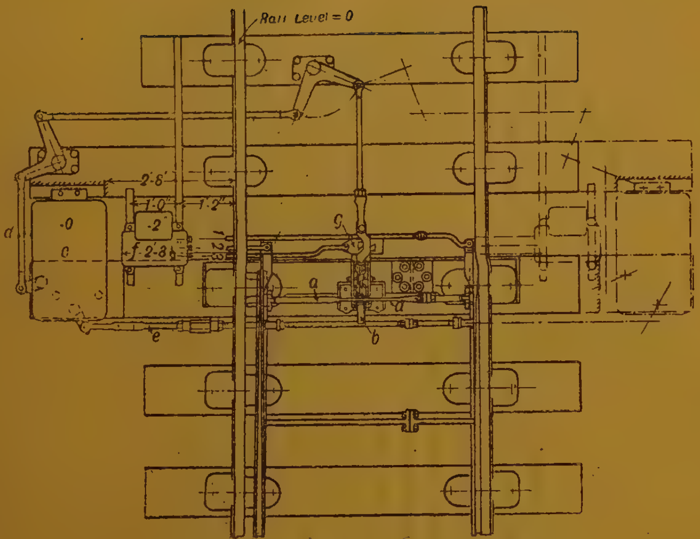


Fig. 4. — Lay-out at a pair of facing points.

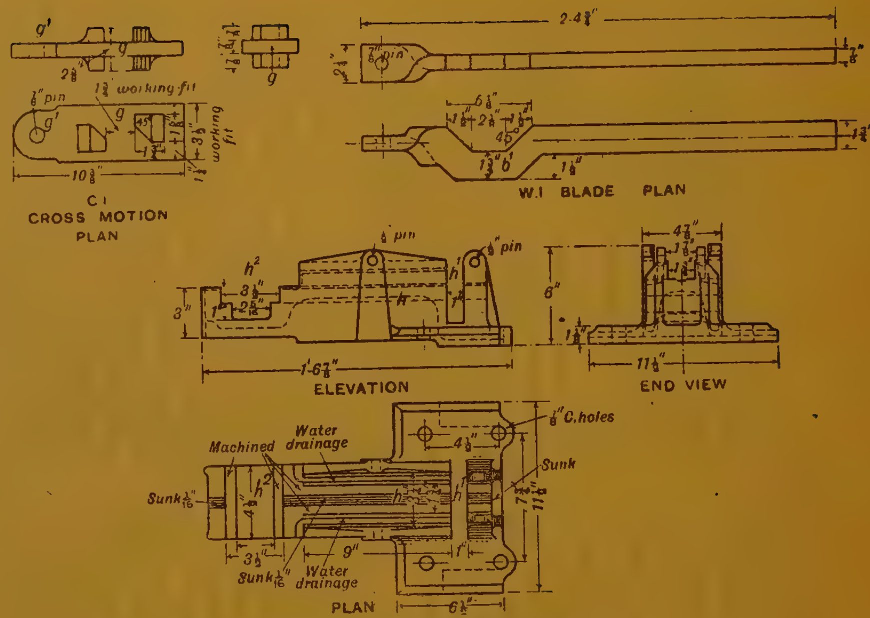


Fig. 5. — Detail of rod 3 in figure 2.

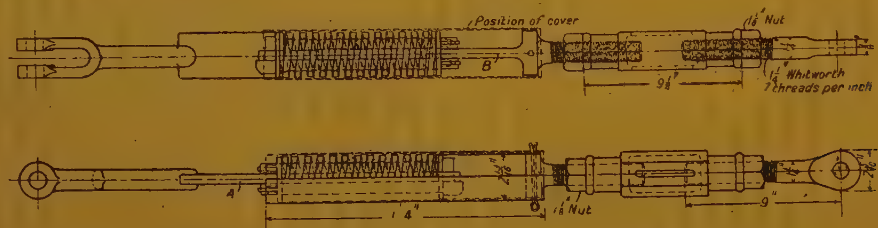


Fig. 6. — Safety spring device to prevent damage to point connections.

11, and 13 and 15 with the route of signal 16.

Signal and point mechanism.

The locking frame is of an entirely new design of Siemens Bros. and Co. All electrical contacts are in the locking frame and work at 24 volts. The contactors, controlling the 120-volt circuits, are in the further cupboard on the left in figure 2, and the switchboard is in that in the foreground on the left.

The signals are provided with Siemens' motors. The point mechanism as fixed to the nearer end — to the box — of No. 18 points, No. 17 trap points, and to the further end of 19, is shown in figure 3. The motor and the detector switch-box in the foreground are for No. 18 points. Those in the background are for No. 19. The covers in the « four-foot » have been temporarily turned back so as to display the plungers.

Figure 4, prepared from a drawing supplied by Siemens Bros. and Co., is a plan of the lay-out at a pair of facing points like 18 or 19. The drawing shows the points facing from the left, whereas No. 18 points, in the foreground in figure 3, are facing from the right. As seen, the stretcher rod *a* (fig. 4) coupled to both switches, is bolted by plunger *b*, so that the first operation of the motor mechanism *c* is to give a right-to-left movement to the rod *d* so that the plunger *b* is completely withdrawn from the stretcher rod. This done, the motor engages with a crank that pulls rod *e* so that the switches are moved over. The motor continues to revolve, and a left-to-right movement is given to rod *d* and the plunger again bolts the stretcher rod, but in the other slot, seen in the photographic view. When the points have to be reversed the same movements are imparted to the plunger, but the points are moved in the opposite direction. The electrical switches that ensure that the motor has done its work are in the box *f*. Rod 1 is coupled to the further switch, 2 to the nearer switch, and 3 detects the plunger movement by means of the plate *g*.

A new facing point lock.

The facing point plunger is the Great Western Company's new pattern, of which the main feature is the manner in which the action of the plunger is detected. It is shown in figure 4 that the third rod 3 for the detector *f* came from the plunger. Figure 5 gives the details of this. The plunger *b* is bevelled at b^1 as shown. Its longer end lies in the casting *h*, and at right angles thereto is the stretcher rod *a* (fig. 4) in the slot h^1. When the points are unlocked the plunger is, as has been said, clear of the stretcher rod. In the recess h^2 lies the cross-motion plate *g* with corresponding bevels to those on the plunger. This plate is at right angles to the plunger — as seen in figure 4 — and not as might be assumed from figure 5. The rod 1 is coupled to g^1, and its operation needs no description.

An interesting detail is the safety spring, seen with its cover removed in the foreground in figure 3. This is an arrangement provided to prevent point connections being damaged should the switches be run through in a trailing direction when closed against such a movement. When that happens the switches are forced over and they and the point connections damaged. There is, too, consequential delay to traffic.

Figure 6 makes the arrangement clearer. The operating rod *d* (fig. 4) is in two parts, the ends of which are inside the cover just referred to. The blade A is coupled to the stretcher rod and blade B to the rod from the signal-box. At the outer end of each are two cotters, and lying between each pair of cotters and around the two blades is a spiral spring. This spring has sufficient resistance to move A and B together, but

is sufficiently resilient to yield to such undue pressure as would fall upon it should the switches be forced over against or away from the rodding. After this pressure had been removed the spring would return the switches to their former position. The blades are slotted so that if compressed they may dovetail.

It only remains for us to express our thanks to Mr. A. T. Blackall, M. Inst. C. E., the signal and telegraph engineer of the Great Western Railway, for an opportunity to inspect and describe this interesting new departure in railway signalling, and to Siemens Bros. and Co., Limited, Caxton House, S. W. 1, for their co-operation.

MISCELLANEOUS INFORMATION

[625 .242 (.75)]

1. — 100-ton Gondola car with four-wheel trucks.

Figs. 1 to 4, pp. 708 and 710.

(*Railway Mechanical Engineer.*)

About two years ago the Pressed Steel Car Company built a sample coal car which was designed especially for transporting coal to be dumped in a car dumper and with the idea of carrying the greatest amount of coal on two four-wheel trucks. The car has a stenciled capacity of 182 000 lb. or. 3 212 cubic feet. When heaped with a 10 % overload, the capacity is 200 000 lb. or 3 703 cubic feet. As the car is always emptied in a car dumper it is not equipped with hoppers or drop doors, being of the flat-bottom, high-side gondola type. The light weight of the car, including the two four-wheel cast steel trucks, is 59 000 lb. and when loaded to capacity the wheel-load on the rail, 64 750 lb. per axle, is somewhat less than the maximum allowed for locomotives. These wheel-loads are greater than has been the general practice heretofore and on this account some doubt has been expressed as to the probability of satisfactory operation. This sample car has now been in service on the Virginian for more than a year and has a record of about 10 000 miles in coal traffic. No undue wear has so far shown up on any of the running gear or other parts, although the wear of wheels and brake shoes has, of course, been proportionately greater than on similar car with six-wheel trucks. The car is reported to have been found satisfactory in all respects. The test shows that it is feasible and therefore more economical to use four-wheel trucks on cars of even such high capacity.

The car is 44 ft. 7 1/2 in. long over striking plates and 11 feet high from rail to top of sides. The inside dimensions of the body are: length, 43 ft. 3 in.; width, 10 ft. 1 1/2 in., and depth, 7 ft. 5 1/2 in.

Except for the substitution of four-wheel for six-wheel trucks, the design is practically the same as that of the 100-ton coal cars used on the Chesapeake & Ohio which were described in the *Railway Mechanical Engineer*, October 1921 [1]. The four emergency drop doors used on the Chesapeake & Ohio cars are omitted, however. In the omission of all bottom doors on high capacity cars designed for unloading by a car dumper, this design follows the practice on the Virginian and the Norfolk & Western.

Of the light weight, 59 000 lb., the body is 35 000 lb. and the two four-wheel trucks 24 000 lb. The two six-wheel trucks used on the Chesapeake & Ohio car weighed 33 400 lb., making the light weight 68 300 lb. and the loaded weight 268 300 lb. The ratio of paying load to the total weight of the loaded car was 74.6 % with the Chesapeake & Ohio design. By substituting four-wheel trucks, there has resulted a saving of 9 300 lb. per car while the revenue load has been increased to 77.2 % of the total.

The sides are free from outside side stakes or other projections outside the plane of the side sheets, thus giving the car a smooth straight surface and at the same time providing for the required cubic capacity in a minimum length and height. The sides are formed of 1/4-inch plates, sloped in near the top at an angle of approximately 15° and then flanged out, overlapping the horizontal leg of the 4 inch by 4 inch by 7/16 inch top angle

(1) See *Bulletin of the International Railway Association*, January 1922, p. 288.

Fig. 1. — Demonstration Gondola coal car of 100 tons capacity.

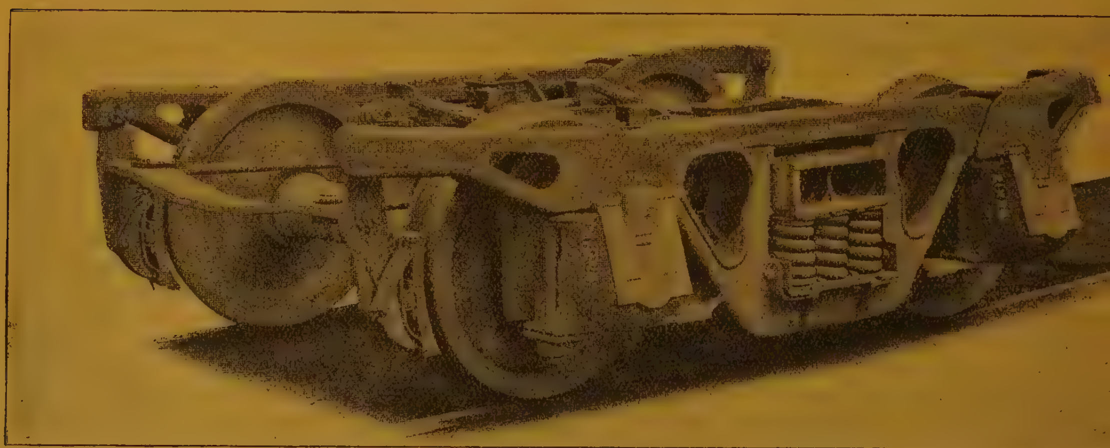


Fig. 2. — Four-wheel truck with cast steel frame and clasp brake.

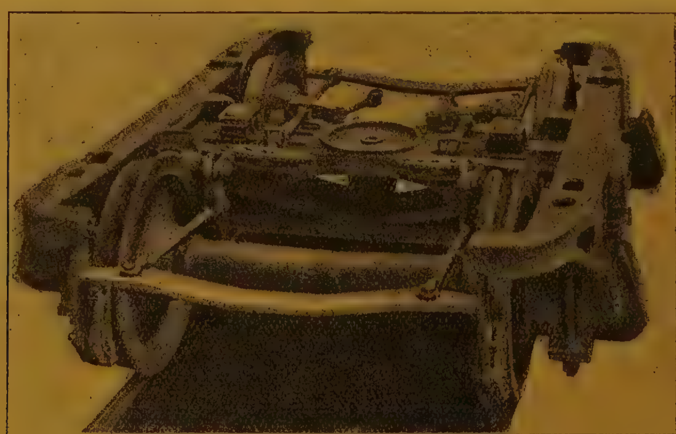


Fig. 3. — End view of truck showing design of clasp brake.

to which they are riveted. With this construction the car is easily cleared of its loading when turned to the proper angle by the dumping machine. Along the bottom, the sides are reinforced by 4 inch by 3 1/2 inch by 3/8 inch angles, which angles also support the floor. Near the ends the side sheets are dropped back into the car to provide space for the ladders and grab irons inside the clearance limits, and to afford protection to ladders in car dumpers and elsewhere. The sides are braced on the inside by 11 1/4-inch gussets on each side and are tied together by two pressed steel cross ties extending from side to side near the top. The ends are composed of 1/4-inch plates reinforced and stiffened by two pressed steel cross braces and a bulb angle across the top.

The centre sills are 12-inch channels weighing 35 lb. per foot, spaced 12 7/8 inches apart and extending from end to end of the car. They are reinforced at the bottom by 3 1/2-inch by 3 1/2-inch by 3/8 inch angles between the rear ends of the draft gear housings. The sills meet the A. R. A. requirements of 30 square inches area and ratio of stress to strain of 0.05. The centre sills are reinforced at the coupler opening with a cast-steel combined striking plate and carrier iron making a substantial arrangement with no chance of the carrier iron becoming loose or the bolt being lost. There are three cross beams in the underframes between the bolsters, made of pressed steel 12 inches deep, substantially reinforced at top and bottom to transmit the load to the sides of the car.

The floor, which is flat throughout its entire surface, is made of 1/4 inch plates and in addition to being supported by the sills, cross bearers, etc., is supported and braced by two pressed steel diaphragms and two 5-inch bulb angles. The body bolsters are of cast steel, 30 inches deep, in one piece, located inside the body and securely riveted to centre sills, floor plates and side sheets.

The couplers are special A. R. A., type D, cast-steel, with 6-inch by 8-inch shank, 24 1/4 inches long with a 5 1/4 inch by 6-inch tail, slotted for a 6-inch by 2-inch draft key. The coupler yokes are of cast steel and the draft gear is of Miner design, type A-18-S.

The trucks are of the standard four-wheel type with cast steel side frames of conventional design. The truck wheel-base is 5 ft. 10 in. and the distance between truck centres is 30 ft. 7 1/2 in. The location of the springs and the method of attaching the A. R. A. standard journal boxes with tiebars, as well as the method of spring plank arrangement, are of the usual design used on practically all modern four-wheel trucks. The cast steel side frame and truck bolster were manufactured by the Buckeye Steel Castings Company, Columbus, Ohio, and are proportioned to the heavy loads imposed.

These trucks are equipped with clasp brakes, thereby avoiding the excessive brake shoe pressures which would have been the case with single brakes for trucks of this capacity. The brake beams are formed of 5 inch I-beams weighing 10 lb. per foot.

The design of the outer brake beam support and the method of attachment to the side frame structure is worthy of special notice. As will be observed from the illustrations, the outside brake hanger bracket at each end of the side frame is a separate casting and is held in place without the use of bolts and rivets other than the bolts which connect the journal boxes with the side frame. The advantage of this construction is that these overhanging parts are separate castings and due to liability of damage in wrecks or derailments, the subsequent loss is not as much as if they were integral with the side frame. It also has added manufacturing advantages resulting in economy of production.

The truck bolsters are of typical Buckeye design with channel section top and bottom members, cylindrical centre post and integral centre plate. The diameter of the latter is 16 inches and width of bolster at ends is 20 inches, with a depth at centre of 14 inches. The spring plank is of built-up channel section design, 14 inches wide at the centre. The web is formed by a plate 14 inches by 1/4 inch, 6 feet long, which is riveted to the 3 1/2-inch, leg of the 4 inch by 3 1/2 inch by 7/16 inch angles which form the flanges beyond the web plate. At each end the angles are spread to

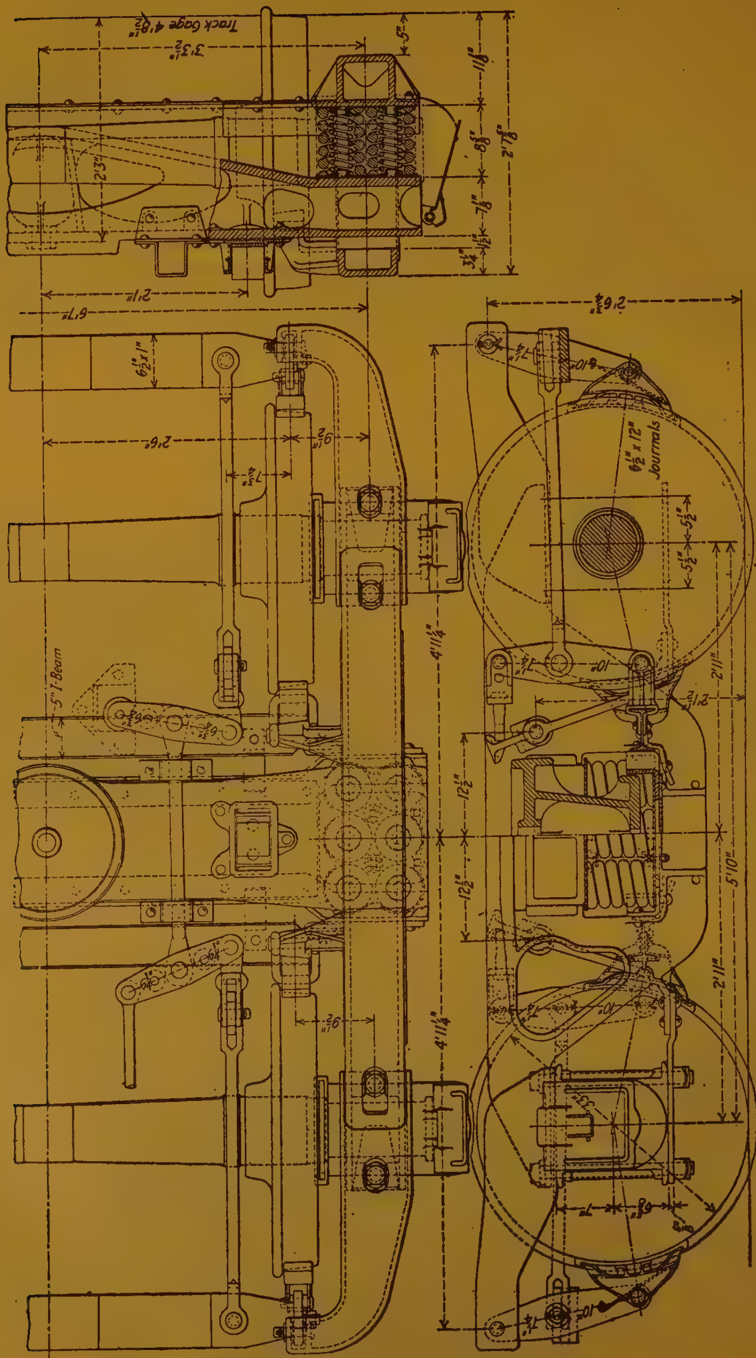


Fig. 4. — High capacity four-wheel truck with clasp brake.

a width of 20 inches to conform to the spring seat construction and width of bolster opening of the side frames to which both the vertical and the horizontal legs of the angles are secured by rivets.

Stucki side bearings with solid rolled-steel roller of 4 inches diameter are mounted on the cast steel bolsters 2 ft. 1 in. to each side of the centre line. Special integrally ribbed construction inside of the bolsters is provided to carry the heavy side bearing loads.

The truck springs have a total capacity of 468 000 lb. per car when solid and consist of four nests, each containing six double-coil helical springs similar to A. R. A. Class D springs, but having outer and inner coil diameters 1-5/16 inches and 11/16 inch respectively and a free travel of only 1-1/2 inches.

The wheels are multiple-wear rolled steel, 33 inches, in diameter and of standard A. R. A. contour. Journal boxes and wedges are of cast steel. The A. R. A. axle capacity for the 6 1/2 inch by 12 inch journals is 60 000 lb. The load on one truck, in this particular car, was considered 120 000 lb. The area of the centre plate bearing surface is 190 square inches.

The car is equipped with Westinghouse empty and load brake, schedule KDE-4-10-16, having a 4-inch take up cylinder, a 10-inch cylinder for use when the car is empty and an additional 16-inch cylinder for use when the car is loaded. The brake rigging is designed to give a 60 % braking ratio on the empty car and 40 % on the loaded car. The wheel loads are 7 375 lb. when empty and 32 375 lb. when loaded. With two shoes per wheel the nominal shoe pressures are 2 212 lb. light and 6 475 lb. loaded, which are not excessive.

[656 .211 (.44)]

2. — Arrangement of stations served with double lines on the Northern Railway of France.

Figs. 5 to 8, p. 712.

(*Revue générale des chemins de fer et des tramways.*)

The new arrangement for stations with double lines as adopted by the Northern Railway of France in rebuilding its stations and goods yards is shown in the following four diagrams, in which are given the respective positions of the main building, and the layout on either side of the level crossing on the up and down sides of the line. The road crossing the line is generally perpendicular to the latter.

In all cases an endeavour has been made to utilise the staff as advantageously as possible, to have a signalling system that is good by reason of its simplicity, and to take special care as far as safety is concerned.

It is of the first importance to be able to shunt into a siding as quickly as possible, any goods trains coming from any direction when it is necessary to have the line clear for a faster train which should have precedence.

In order to accomplish this, it is an essential condition that as soon as the slower train has been received, it should be backed into its siding without sending it « too far », and especially to avoid blocking the main line adjacent to that on which it is running.

To achieve this, it is necessary to have independent siding accommodation for each direction in which the trains run, and which sidings may if necessary have dead ends.

On the other hand, it is important that when a train has to be shunted for some time, its engine may be used for the various duties in the goods yard, such as disposing of wagons it has brought along, and picking up others that it may have to take on further, and also put into proper order wagons that have to proceed by another train in the opposite direction.

Finally, it is absolutely necessary that the crossings connecting the main lines to the sidings on each side of them are as near the

principal building as possible, so that all the operations taking place on the main line and in the signal boxes which protect them may be easily supervised by the foreman in charge, who will thus have them almost constantly under his eye. By this method, the number

Fig. 5.

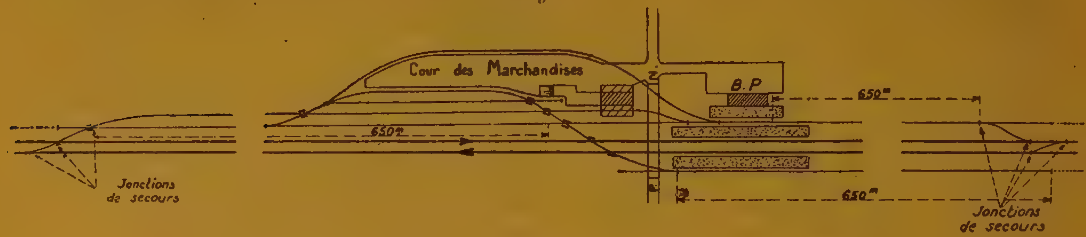


Fig. 6

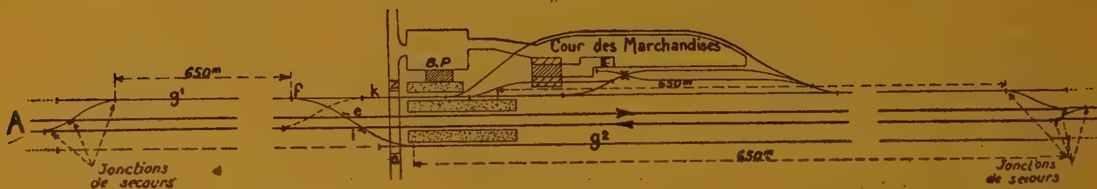


Fig. 7.

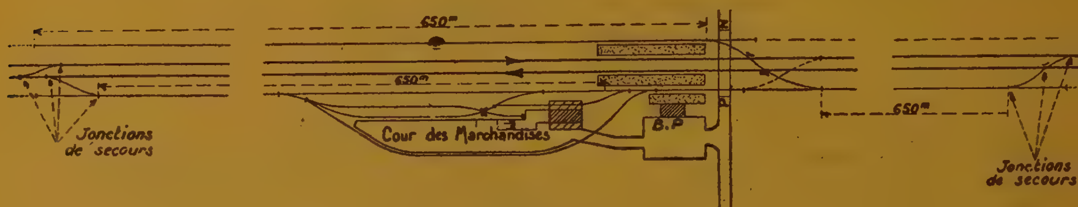
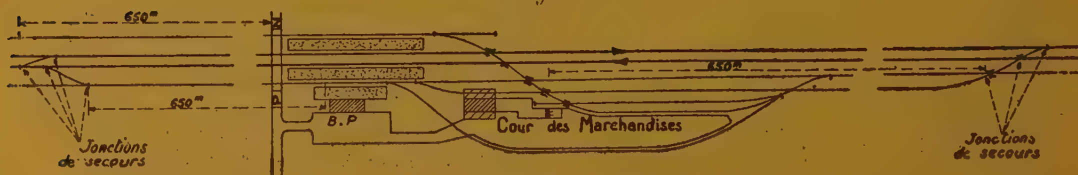


Fig. 8.



Figs. 5 to 8.

Explanation of French terms : Cour des marchandises = Goods yard. — Jonctions de secours = Crossings used in case of necessity

of signals, connections and bell controls is kept low, so that great simplicity is obtained in addition to greater security.

On the other hand, it often happens at a station that it is necessary to send wagons to yards situated on both sides of the line without blocking the main lines unnecessarily. In many cases it is the main line which comes alongside the principal building, because it has not been possible to put in an accessory line. In such cases, in order to pass from a yard in the up direction to one in the down

direction, it is necessary to make use of the main down line, and when working in the reverse direction, to first of all cross the main up line twice at the beginning of the operation, and also the main down line twice at the end of the operation.

It was in order to find a solution to the problem and do away with this inconvenience that the arrangements shown in figures 5 to 8, as typical examples, have been designed, and we will explain how they are utilised by referring to figure 6.

A goods train arriving from A is immediately backed by means of the crossing *ef* into the siding g^1 specially arranged for the purpose on the left, which is essential on account of it being necessary to clear the main line as soon possible. This is the first phase of the operations.

The goods train being thus placed out of the way, the front portion is uncoupled and passes forward along the line *k* in order to do the required shunting in the yard. The work being finished, this portion returns to the rest of its train left on g^1 and waits until it may leave. This being the second phase.

The time for departure having arrived, the train runs on to the main line over crossing *fe* under the eyes of the station-master himself. This being the third and final phase.

For trains coming from the opposite direction, a fourth phase is often necessary, because when the shunting operations are finished in the yard, the engine cannot always return directly on to its train, but may have to wait until both main lines are clear. The procedure is then as follows :

First phase. — Immediately shunted by means of crossing *i* into the right hand siding g^2.

Second phase. — The front portion of the train, which has been shunted as soon as both lines are clear, crosses to the other side by means of *ifk* in order to do its work in the yard on the south side.

Third phase. — After it has finished, this portion returns through *fei* to be coupled up to the remainder of the train waiting on g^2.

Fourth phase. — Finally the train starts, regains the main line and proceeds on its journey.

The figures show also, at the far ends of the station, crossings between the main lines and the sidings which have been spoken of as being usually fitted with dead ends. These connections, however, are only used in cases of accident and not in ordinary working, and normally are only used when something gets off the line in the station. They in fact provide accommodation which had to be arranged during the war on lines with heavy traffic, like that at Boulogne for instance, the junction with the main line being made 500 m. (550 yards) from the station so as to reduce the distance of piloting. They are thus very well placed for the work they were expected to do in case of necessity.

It will be seen that by this means piloting through the lie-by can be effected very quickly by the chief foreman of the yard without having to call for assistance from the nearest stations in either direction, and consequently the work is carried out in a much quicker and safer way.

These arrangements make it possible to work a service of pick-up goods trains running short distances, the locomotive of which can also carry out the marshalling and shunting of wagons at each station it stops at. For this purpose a gang of experienced shunters accompanies the trains, making it unnecessary to have, at certain stations — with the exception of the foreman responsible for safety in working — anyone beyond the usual staff of clerks, checkers and porters.

It must not, however, be thought that doing this means that the first stage of quadrupling the line has been accomplished.

It was something to have had the foresight to place the principal buildings further away in order to bring this quadrupling within the limits of possibility, but in any case the line placed between the buildings and the first of the main lines is above all a line for local traffic. This may be lengthened on each side of the station according to requirements in order to couple up to branches which may be some distance away from the crowded centre

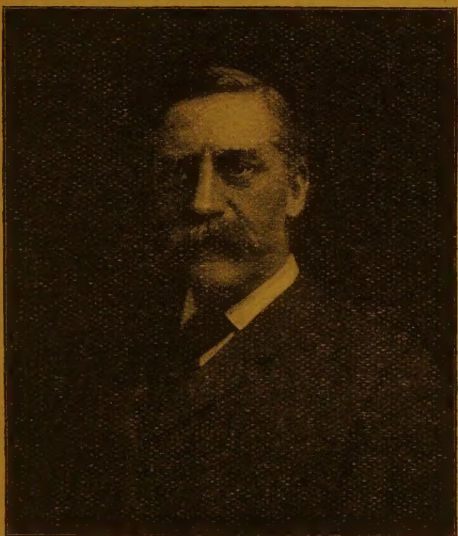
that has to be supplied and where there may be only room to fix a workshop and workmen's houses. By this means it is always possible to be in direct communication with the station, when a connection directly with the main lines would not be allowed.

The line running in front of the main building is rather a service line than a line for circulation of trains, and differs from the latter by the fact, that instead of requiring an excavation being made in the roadway with a space on each side, it is laid down level with the roadway itself like tramways in the streets, and lines in harbours, which have to be crossed by vehicles. In this way there is all the freedom necessary in front of the main building for passengers and dealing with luggage or such articles that have to be placed in or taken away from the trains, this line being only used for passing from one end of the station to the other at intervals which are often many and long between the times when passenger trains are making use of the latter.

OBITUARY

Stuyvesant FISH,

Director of the Missouri, Kansas & Texas Railway;
President of the seventh session (Washington, 1905) of the International Railway Congress Association;
Life member of the Permanent Commission of that Association.



We have learnt with the deepest regret of the death of one of our most esteemed and sympathetic American colleagues, Mr. Stuyvesant Fish.

He was elected a Life member of the Permanent Commission of our Association after the very successful session in Washington in 1905, at which session he acted as President with such distinction.

We reproduce below a memoir of him which appeared in the *Railway Age*, and we offer to the family and numerous friends of the colleague, whose decease we so deeply regret, our sincerest sympathy.

The Executive Committee.

Stuyvesant Fish, of New York, from 1887 to 1907 president of the Illinois Central and prominent in railroad financial affairs up to the day of his death, died suddenly of heart disease in New York on 10 April, at the age of 72. Mr. Fish was born in New York City and had lived there all his life. He was a clerk in the New York office of the Illinois Central and later served as secretary to the president. About 1876 he was elected a director of the company and took a prominent part in the operations leading to the acquisition of the lines south of the Ohio River, which now form that part of the Illinois Central System. He was chosen second vice-president in 1883, first vice-president in 1884 and president in 1887. His retirement after twenty years of successful management was due to the acquisition of control of the stock of the road by E. H. Harriman, which change was accompanied by acrimonious strife extending through several years. He was afterward interested in other railroads and was a director in the Missouri, Kansas & Texas at the time of his death.

Many railroad men will remember Mr. Fish principally through his connec-

tion with the American Railway Association of which he was president in 1905. The year in which that association entertained the delegates to the International Railway Congress on the occasion of the meeting of that Congress at Washington. Since then M. Fish has been a member of the International Railway Association. The visit of the European delegates to America in 1905 was the only occasion on which the American Railway Association ever exercised a notable social function, and Mr. Fish was perhaps its only president who combined the requisite personal qualities, that is, he was a railroad officer a millionaire, and a leader in social life. And, as was observed by a biographer who knew him, he had more than wealth, lineage and brains; he had character.

NEW BOOKS AND PUBLICATIONS

[625 .14 (02 & 385. (04]

HEPWORTH (W.), associate member of the Institution of Civil Engineers, & LEE (J. T.), member of the Permanent Way Institution (Gold medallist). — **Railway permanent way.** Dimensional theory and practice. A manual for engineers, inspectors, foremen, etc., with tables. — One volume (7 × 4 3/4 inches) of XVI + 404 pages, 50 tables and figures in the text, and 7 full page photographs. — 1922, Chas. Sever, 40, King Street West, Manchester. — Price : 12 s. 6 d. or 13 s. post free.

Questions dealing with permanent way are described in this work in a very practical manner. Numerous sketches are used which illustrate the text very clearly and a number of complete tables deal with the theoretical portion of the work. All problems are dealt with in a very simple manner, with numerous numerical examples. The work as a whole will be found useful by practical men.

After a very interesting introduction dealing with the general methods of permanent way, the authors give a series of definitions and dimensions relating to rails and permanent way. Mathematical formulæ are given in connection with the more complicated problems, such as those of curves and junctions, which are extremely well dealt with in this work. Tables relating to calculations for points and crossings are also given.

J. V.

[621 .137.1 (02 & 385. (04]

BRILLIÉ (E.), engineer of arts and manufactures, technical adviser to the firm of Merrs. SCHNEIDER & Co. — **Manuel du mécanicien et du chauffeur de locomotive (Text book for locomotive drivers and firemen)**, for the use of staff operating locomotives and technical school students. — A large volume 8vo (7 1/2 × 5 inches) of XII + 164 pages, with 107 illustrations in the text or on plates. — 1921, Gaston Doin, publisher, 8, place de l'Odéon, Paris. — Price : 10 francs.

As the title shows, this book is intended for those in charge of the working of locomotives. It is intended to give them the essential points which govern the construction and working of a locomotive, so that they may be able to understand the instructions given them easier. It in addition deals with the chief details of the organisation in sheds and of the running of the locomotives in service.

The work is divided into two parts, the first dealing with the description of the locomotive itself, and the second with its working.

In order to attain this object, the author has very wisely omitted detailed descriptions which can be found in other books of a different character and object. He has laid himself out to give in a clear and concise manner the work and general arrangements of each part. The subject matter is illustrated by drawings to scale of the essential parts; the vari-

ous drawings of the whole locomotive, of certain apparatus or of groups of parts, often have the various names given so that they are understood easily. One may mention, in passing, a diagram which shows that the movement of a slide valve regulator is very different from the movement of the handle whose movement opens it. The first part of the book ends with a chapter showing the principal types of locomotives and in which are brought together a certain number of characteristic outlines and diagrams.

The second part deals with the working of the engines, the manipulation of the fire, the attention to be given in the shed and the behaviour and points to be observed during the run. The author also deals with each special portion of the work of the locomotive staff during the whole time they are on duty, and this is not the least interesting part of the book. After dealing with a few practical points on firing, he then passes in review the various operations carried out at the shed, such as cleaning, repairing and supplying stores to the locomotive so that it may be in the best condition for carrying out its work. His explanations are accompanied by numerous useful hints and practical suggestions.

This book ought to be of the greatest assistance to drivers and firemen, and be of real interest to all those interested in the steam locomotive.

E. M.

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COURTEN (Mustapha Ibrahim Bey de), colonel of engineers, late chief engineer of the Way and Works Department of the railways of Lower Egypt. — **Les chemins de fer à voie d'un mètre (Metre gauge railways).** — One large volume 8vo (8 3/4 × 12 inches), 336 pages, with 270 illustrations in the text, 5 plates and tables. — 1922, Dunod, publisher, 47 and 49, quai des Grands-Augustins, Paris (VIe). — Price : 30 francs.

The considerable development which has taken place, owing to the employment of metre gauge railways, in the new parts in Asia, Africa, Australia and in America, fully justify a volume of information on railways of from 0 m. 90 to 1 m. 067 (from 2 ft. 11 1/2 in. to 3 ft. 6 in.) gauge.

The reduction in the gauge of the railway has no detrimental effect, as the author shows, on the intensity of the traffic. The metre (3 ft. 3 3/8 in.) gauge railway has a number of advantages, such as the reduction in the cost of construction and of rolling stock, quicker construction and economy in operation.

The work is divided into two parts. In the first of these the author deals with metre gauge lines from a theoretical standpoint. This is dealt with in three chapters : Formation, Superstructure and Rolling Stock.

In the second part is found a resume of the practical results obtained in Africa, America, Asia, Australia and Europe.

J. V.